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Pioneer All-Electric Coal Mine

MAKING SLATE AND DIRT FROM TIPPLE REFUSE DO HEAVY HAULING AND HOISTING

KNOWN AS the New North Mine of the Christopher Coal Mining Co., at Christopher, Ill., is a bituminous mine which recently produced a daily output of 4923 tons and established a record for southern Illinois. Moreover, it has the distinction of being the first large coal mine in the United States to be operated entirely by electricity, as it was the first to employ a motor-driven hoist.

and continuous power service is necessary to guard against enforced idleness.

Electricity is employed here to cut, haul, hoist, screen and convey coal, light terminals, sidings and workshops, drive dewatering pumps, operate ventilating fans, telephones, signals, etc.

Coal is cut with 30 cutting machines, each of which is operated by a 30-hp. d.c. motor. Haulage is accomplished with 16 G. E. electric locomotives, 14 of which

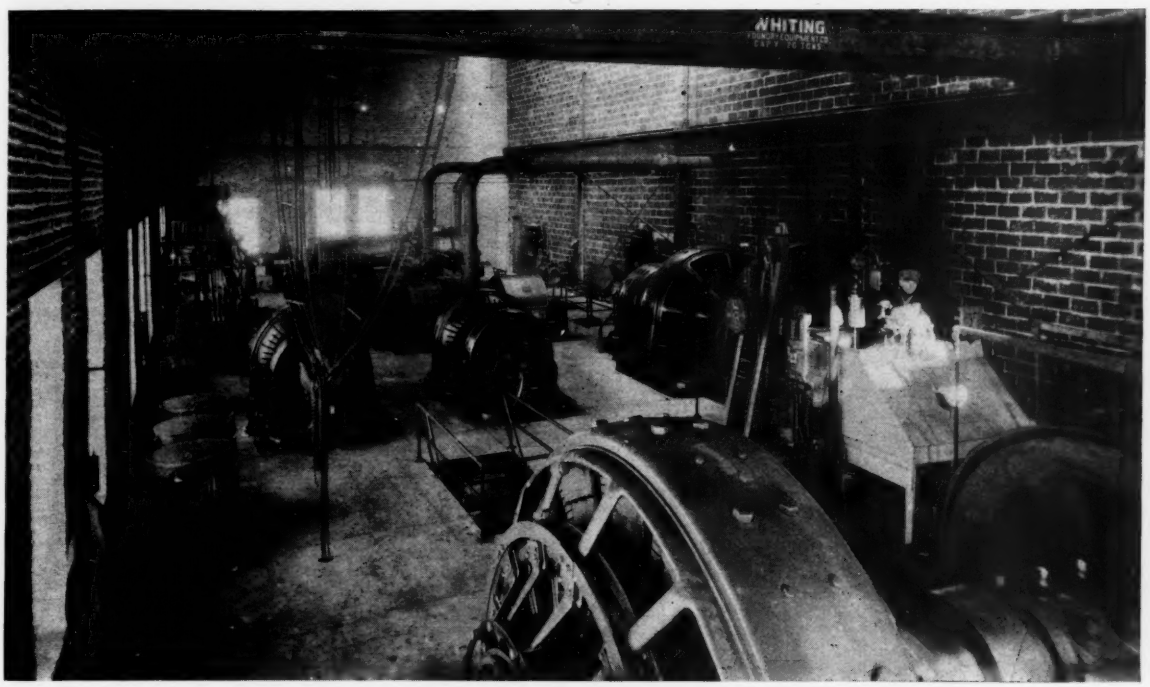


FIG. 1. INTERIOR VIEW OF POWER STATION

In coal mine operation where large quantities of coal must be handled with dispatch and safety, a well-considered and smooth running power system is of great importance. The New North Mine employs 600 men

are known as "gathering motors," as they gather the loaded cars and bring them to a siding along one of the main passageways. They weigh 6 tons and are driven by 2 30-hp. d.c. motors, one on each axle. Draw-

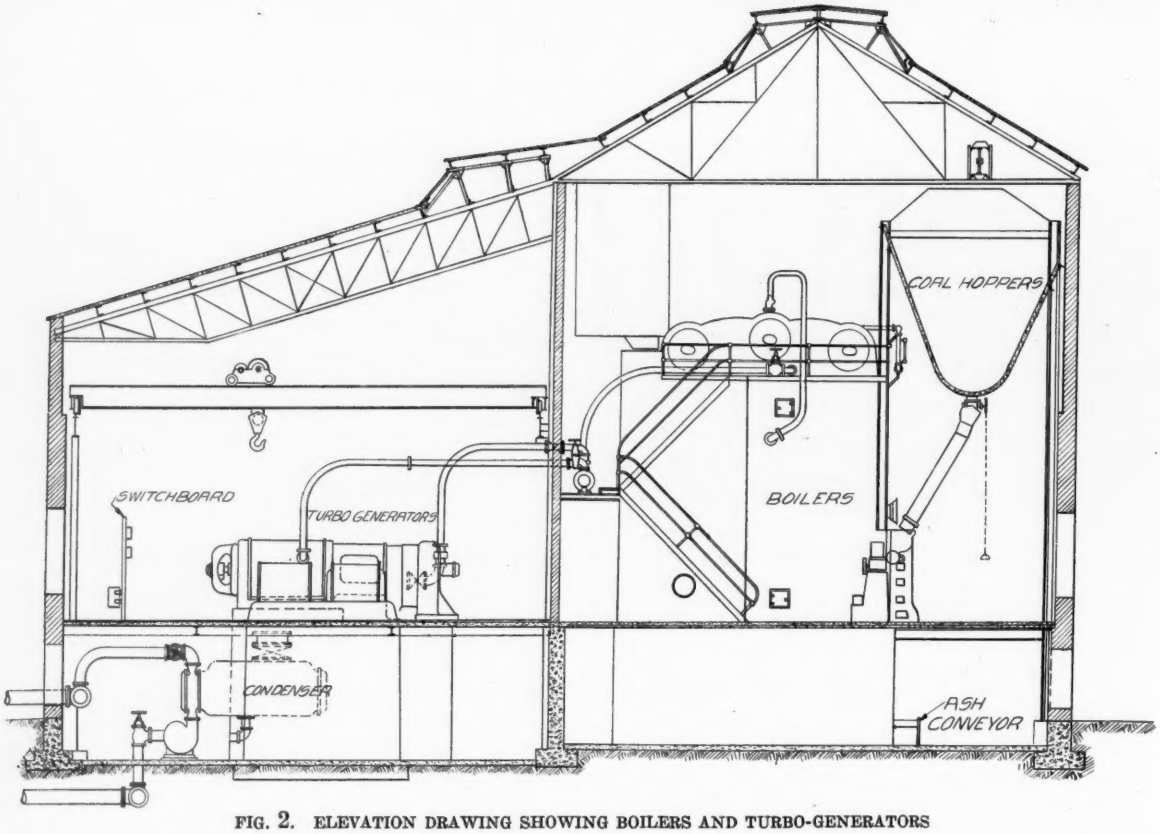


FIG. 2. ELEVATION DRAWING SHOWING BOILERS AND TURBO-GENERATORS

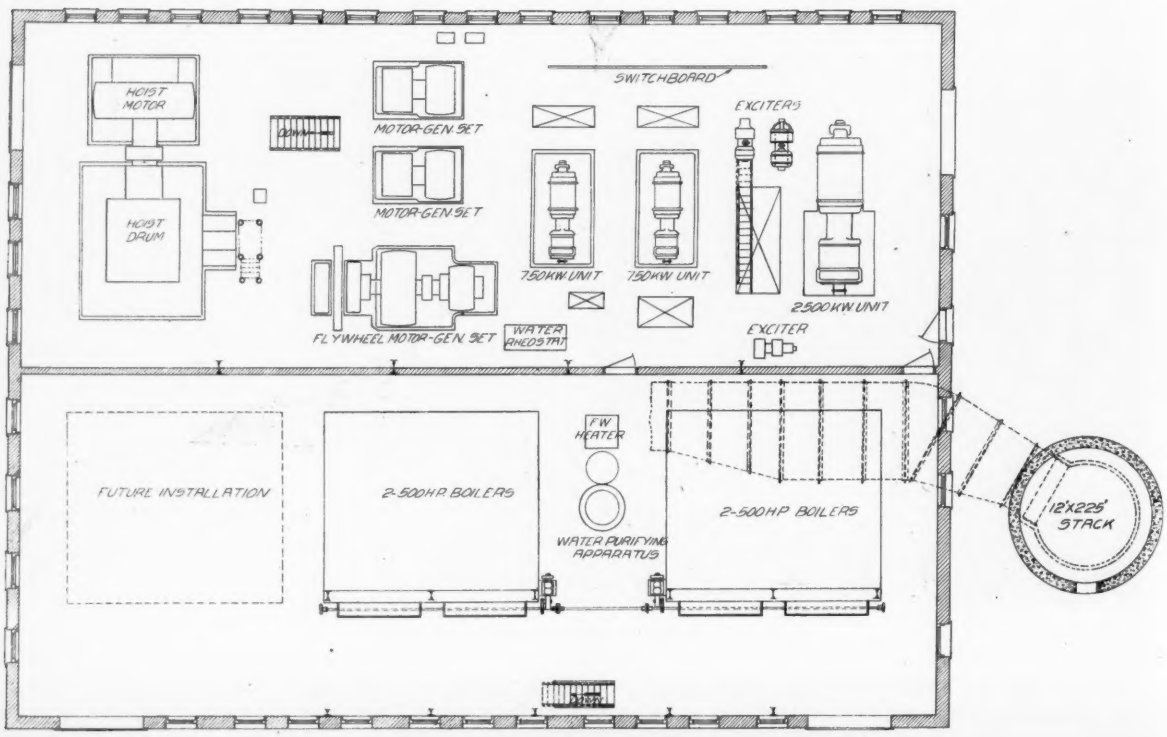


FIG. 4. PLAN VIEW SHOWING ARRANGEMENT OF UNITS

ing the trains of loaded cars to the main entry are 2 G. E. 15-ton locomotives each of which is equipped with 2 85-hp. d.c. motors.

As it would not be practical to install and continually extend the trolley wires into the mining chambers, the gathering locomotives are equipped with a flexible insu-

FIG. 3. FIRING AISLE OF BOILER ROOM

lated cable which is hooked on to the main haulage-way trolley wire and as the motor goes into the chamber the cable unwinds from a horizontal reel which is placed on top of the locomotive frame.

It is well recognized that the haulage system has an important bearing on the cost of mining coal, and more intensive mining and larger daily outputs are now made possible because of the high speed and flexibility of the modern electric haulage system.

Lighting of the main entry where cars are run to the hoisting shaft is novel and efficient. Indirect illumina-

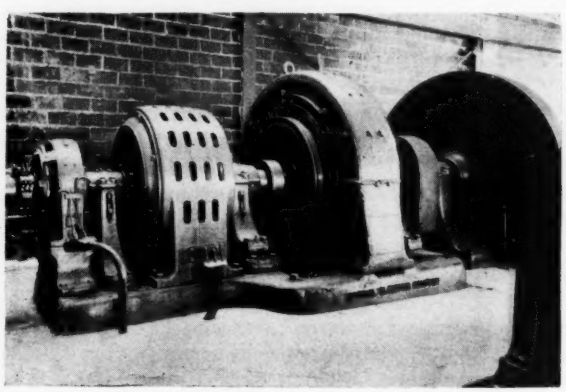


FIG. 5. FLYWHEEL MOTOR-GENERATOR SET

tion is employed, 150-watt tungsten lamps being placed flush with the cross I-beams which support the roof. Thus, the men handling cars where the traffic is greatest are not exposed to glaring lights. Approximately 200 lamps from 50 to 150 watts are used in the mine.

Coal arriving at the top of the hoistway is tipped into the weighing basket, whence it begins its journey through the various screens and picking tables where it is sorted and the refuse removed. Operating the various shakers, conveyors, crushers, etc., of the tipple are 17 a.c. motors ranging from 3 to 50 hp., which are supplied with 220-volt 3-phase current. Also operated by the same company and at a distance of about 2 miles, is another mine which receives from this plant current to operate a 650-kw. load.

Boiler House Equipment

Steam is supplied by 4 Stirling boilers, each rated at 500 hp., maintaining pressure at 165 lb. and equipped with Foster superheaters giving 100 deg. of superheat.

Roney stokers are employed to feed coal to the furnaces while draft is furnished by a concrete stack, 225 ft. in height, of 12-ft. interior diameter. Each boiler is equipped with a Blonck efficiency meter and a mechanical soot blower. The fuel used is about 75 per cent refuse from the picking tables, sweepings, etc., and 25 per cent screenings. In the early history of the mine this tipple refuse was hauled away at a cost of 10 cents a ton. Flight conveyors in the tipple carry the refuse

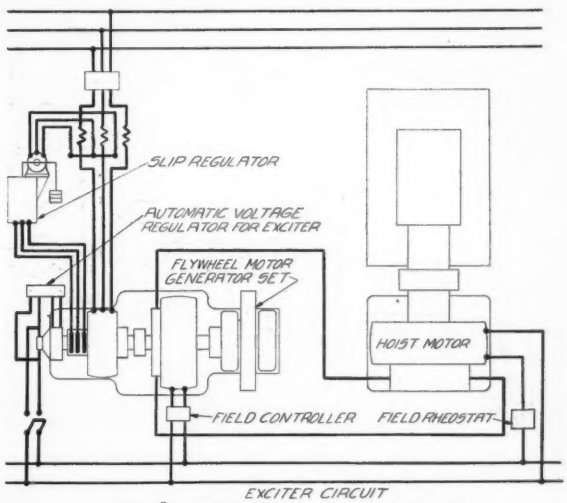


FIG. 6. ILGNER BALANCING SYSTEM

to a 50-ton steel bin from which it is discharged into a 2-roll motor-driven crusher, and again conveyed by a flight conveyor from the tipple to the boiler room hoppers, a distance of about 220 ft. Each battery of 2 boilers is equipped with a 100-ton concrete lined steel bunker. Space is provided in the boiler room for the future installation of 2 additional boilers as shown in Fig. 4.

Ashes are drawn from doors in the ash hoppers on to a 24-in. flight conveyor which has a slight incline outside the boiler house from which the ashes drop through a chute into the removal cars.

Makeup feed water is drawn from a pond and is passed through a Vater purifier to receive a soda ash and lime treatment, and then flows through a sand filter. A Cochrane feed-water heater and a 5-in. Venturi meter are provided.

To give the fireman an indication of the load being carried by the generators, a kv.a. meter, which is connected through a current transformer to the main 2300-volt, 3-phase a.c. bus bar, is installed in the boiler room. It is an ammeter with a scale so designed and provision made for an average power factor so that the direct scale readings give approximately the load in kilowatts.

Turbo-Generators and Motor-Generator Sets

Carrying the bulk of the load is a 2500-kw. G. E. generator delivering 60-cycle alternating current at 2300 volts. This machine is driven by a 4-stage Curtis steam turbine operating at 3600 r.p.m.

Chiefly for off-peak loads are 2 750-kw. G. E. generators which also deliver 60-cycle, 2300-volt alternating current, each of these machines being driven by a 2-stage Curtis turbine operating at 3600 r.p.m.

Excitation current is supplied by 2 motor-driven and 1 turbine-driven generators. A 35-kw. and a 17-kw. machine are driven by 50- and 25-hp. induction motors, respectively, and a 15-kw. generator is driven at 4500 r.p.m. by a 25-hp. steam turbine.

Trolley circuit current is drawn from one of 2 motor-250-275 at the d.c. terminals. The motors are synchronous and each is rated at 430 hp. Operation of the mine locomotives is sufficiently uniform to prevent any dangerous overloading of the synchronous motor-driven generators.

FIG. 7. HOIST MOTOR AND DRUM

Supplying direct current at 550 volts to the 1150-hp. G. E. motor which operates the 7-ft. main hoisting drum, is a flywheel motor-generator set, shown in Fig. 5, which consists of a 650-hp. induction motor and an 885-kw. generator. Varying the speed of the flywheel about 15 per cent causes it to give up or absorb energy according to the demands of the hoist, thus making the load upon the line more uniform.

Figure 7 shows the hoisting motor and drum and the hoist operator's platform. At one side of the drum is a dial which indicates the levels of the ascending and descending cars.

Ilgner Balancing System

Speed of the motor-generator set is controlled by the Ilgner balancing system in which the field of the generator is separately excited, and a controller is provided so that the excitation and polarity of the generator can be varied as desired. The field polarity of the hoist motor remains constant so that by reversing the armature current the direction of rotation is changed. By varying the excitation of the generator, the voltage applied to the armature of the hoist motor is varied, thus changing the speed of the hoist. Wiring connections for this system are shown in Fig. 6.

Automatically inserting resistance into the rotor circuit of the induction motor is a slip regulator which consists of a 3-phase water rheostat operated by a small motor in series with the main induction motor. When the load on the generator is reduced below the value for which the automatic regulator is set, the flywheel speed is increased by automatically removing, through the water rheostat, the resistance in the rotor circuit of the induction motor. When the load on the generator exceeds the value for which the regulator is set, resistance is automatically inserted in the rotor circuit, thereby allowing the induction motor to "slip" or decrease in speed and permit the flywheel to give up part of its energy.

Normal speed is recovered by dynamic braking and by current from the switchboard during the rest period of the hoist motor. Two cages are operated by the hoist, one descending as the other ascends, the rest period under normal operation being 6 or 7 seconds.

Operating the 5-ft. hoisting drum of the single-cage auxiliary shaft is an 18 by 40-in. Litchfield steam engine which is housed in a separate building and receives its steam through a 3-in. asbestos covered line.

Pumps and Condensers

Boiler feed water is handled by an Alberger 4-stage centrifugal pump operated at 2500 r.p.m. by an Alberger-Curtis turbine. A 10 by 6 by 12-in. Gardner duplex pump is provided as an auxiliary feed pump.

Service water is supplied by a Goulds 4-in. centrifugal pump, which, driven by a 20-hp. a.c. motor, at 1800 r.p.m., forces 275 g.p.m. through a 6-in. cast-iron line from a pond about ¾ mile from the plant.

Two classes of work are performed in dewatering a mine; one is the handling of the water at the main or permanent pumping station, the other is its removal from the entries, slopes and shafts, where work is continually advancing and the length of the suction and discharge constantly changes.

Near the base of the air shaft is the permanent dewatering pump, a 4 by 6-in. Goulds triplex, which is driven by a 25-hp. a.c. motor. It lifts the water to the surface 600 ft. distant through a 3-in. discharge. Most of the water handled by the pump, however, is not forced to the surface, but is utilized for sprinkling in the mine.

For portable gathering pumps are 2 Goulds 3 by 4-in. triplex pumps, each of which is driven by a 7½-hp. d.c. motor. These portable pumps are mounted upon cars, and force the water to the main sump at which it is handled by the larger permanent pump.

Vacuum for the 2500-kw. turbine is provided by a Wheeler rectangular surface condenser with 14-in. cast-iron inlet and outlet lines. Cooling water is circulated by a 14-in. centrifugal pump, and the air and condensate are removed by a Wheeler combined turbo air pump. Direct-connected to a common shaft and driving both pumps at 2000 r.p.m. is a 150-hp. Curtis turbine.

Two Wheeler rectangular surface condensers serve the 2 750-kw. units having the cooling water for each circulated by an 8-in. centrifugal pump operated at 1200 r.p.m. by a 75-hp. Terry turbine. Inlet and outlet lines of each condenser is 8-in. cast-iron pipe. Water is cooled by means of a spraying pond which is provided with 76 3-in. Schutte and Koerting nozzles.

Ventilating Equipment

Air for mine ventilation is supplied by a 6 by 12-ft. Jeffrey centrifugal fan which is driven by one of 2 150-hp. 3-speed induction motors. These motors are connected to a common shaft and provided with friction clutches to throw them in or out of service. Driving the fan shaft is a 24-in. 6-ply rubber and canvas belt, the distance between pulley centers being 22 ft. Ordinarily, 200,000 cu. ft. of air per minute is forced down the 10 by 10-ft. air shaft.

Distribution System

From a 17-panel black slate switchboard, which is provided with the usual indicating, regulating and switching apparatus, 2 750,000-circular-mil lead-covered cables pass down the main shaft and feed 2 trolley circuits. Trolley current is 250 volts d.c. and carried on 0000 wire which is rolled in the shape of a figure 8, the supporting hanger gripping the wire in the grooves. Where long runs occur, one or 2 bare auxiliary 0000 feeders are carried to feeding points and tied to the trolley, so that the voltage drop seldom exceeds 20 per cent.

Negative current returns to the power house through 4-48-lb. rails which are bonded and cross-bonded with 0000 copper wire, the bonds being concealed.

Sectionalizing switches are used in the feeder circuits and trolley lines at such points as may be necessary to permit cutting off the power in the various circuits when not in use or in the event of accident.

Another lead-covered cable connects the switchboard with the 220-volt 3-phase 60-cycle circuit which runs along the main passageway between the 2 shafts.

Approximately 25 per cent of the electrical output of this plant, largely off-peak current, is sold to a public service company, after being passed through a set of 3 600-kw. step-up transformers and delivered at 33,000 volts to their branch line which extends to the power house.

Nine men operate the power station. Each one of 3 shifts is taken care of by one fireman and one engine room operator, while on each of 2 shifts a man is employed who operates the ash-handling system and regulates the feed-water treatment apparatus. The ninth man attends to the coal-handling equipment which is operated only during one shift.

Much has been done by the electrical engineer, A. W. Spaht, who is in charge of the plant, to establish and maintain a record for efficient and economical power generation which is far ahead of the average coal-mining power station.

Correcting Turbine Vibration---I

How to Size It Up: The Causes and Remedies. By Eustis H. Thompson

With the processes of manufacture so perfected as at the present time, vibration troubles in impulse turbines are conspicuous by their absence. The published information on vibration, however, seems quite incomplete. The following descriptions and analyses are prompted by a first hand knowledge of the subject, and various phases are illustrated by concrete example rather than being deduced by complicated steps of reasoning.

The old saying, that "if a turbine set is lined up right and balanced right it will run all right," appears to be true in 95 per cent of turbine troubles; however, the methods of applying these rules are sometimes considerably more difficult than one would imagine at first sight.

To distinguish between the vibration caused by an unbalanced rotor, and that cause by bad bearing alinement, is not difficult, in most cases. Unbalanced vibration is essentially a uniform shake that gets slightly better as the load is applied. It has the same periodicity as the speed, or, in other words, the bearings are displaced by the shaft once at each revolution. When present in excess, however, the violent vibration becomes slower and more variable, due to the action of the bearing pedestals which do not respond so quickly to the larger deflections. Bad bearing alinement causes a vibration of slow and variable periodicity, due to the action of the bearings. This vibration is usually absent at no load, but increases directly as the load is applied. In specially bad cases, some vibration may be present at no load, but it gets much worse as the load is increased, sometimes causing heating of the bearings.

To size up vibration the following points should be investigated: Where does the greatest vibration appear? Is there any heating or special noise noticeable? Is the vibration of a high, low, variable or steady periodicity? How is it affected by starting, stopping, adding or subtracting load, or varying field of generator? Is there water, sediment or acid in the steam? Is the machine a stout one of a few stages, or a sensitive one of many stages? If these points are compared with the analysis and discussion a strong clue should easily be obtained.

Out of Line Vibration

Case 1. A 500-kw. turbo-generator set, with 4 bearings and 2 couplings, running about 2000 r.p.m., at times showed considerable vibration. It usually ran perfectly, but on some days the operation was very bad indeed. This had been in operation about a year. An inspection of conditions revealed that the vibration occurred at the heaviest loads, and was of a slow, variable periodicity. This gave a strong clue to the trouble, so the couplings were checked for alinement, and found to be badly out. The pillow blocks were shimmed so as to bring the couplings parallel and central, and the vibration never appeared again.

Case 2. A 500-kw. 3-bearing set when first put in operation would run O. K. for a while, and then take a vibration spell that would last until shut down. No vibration appeared when operated noncondensing, or

when the turbine was heated up to start; but when it had reached a running temperature condensing, the trouble would appear. Noise in the wheel casing was another clue, and on checking the alinement of the wheel casing it was found to be too low, allowing the internal packing to bind. The casing was alined so as to be central with shaft when hot, and this trouble was eliminated.

Case 3. A 300-kw. 2-bearing turbine was placed on an extremely flexible steel foundation. It showed considerable vibration, at no load, and this increased at times and was quite variable at no load. The high periodicity showed unbalance to a large extent, but the variable character indicated bad alinement. The wheel casing was checked and found to be nearly ⅛ in. low at one end due to faulty installation. The internal packing was not binding, apparently, but bad alinement of nozzles and moving blades was responsible for this. It is probable, however, that if the machine had been on a concrete foundation this bad alinement of nozzles would not have been noticed. After correcting alinement and balance the operation was O. K.

Case 4. A turbo-generator set would vibrate at intervals after being started. Sometimes it would run several days and sometimes only several hours before

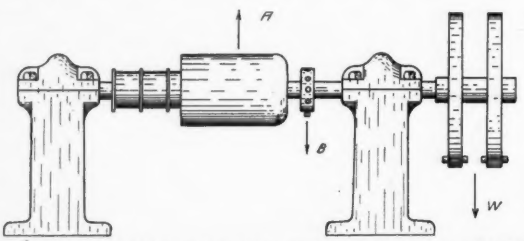


FIG. 1. METHOD OF BALANCING WHICH PROVED A FAILURE

taking a spell. The shake was a violent one of low periodicity, and appeared most intense at one end of the set. It seemed very difficult to diagnose. The bearing at this end ran a very little warmer than the others. Upon examining the bearing that vibrated most, the self-alining bearing was found to be clamped too tightly, so that it would not change its position according to the needs of the shaft. The ball joint was filed 0.002 in., allowing it to move freely, and the trouble was eliminated.

Bad alinement of the magnetic elements would probably cause vibration in a sensitive machine, although the writer has never heard of nor seen such a defect causing vibration.

Bad alinement of governor parts, small shafts, gears, etc., usually do not affect the general operation of the machine, but tend to cause local heating or disturbances.

Outside agencies, such as piping strains due to weight or expansion, settling of foundations, etc., frequently cause out-of-line troubles. These matters are usually quite easy to check up and remedy.

Vibration Caused by Unbalance

Balancing is a science in itself. In modern factory practice, where the methods have become so developed and perfected, uniformly good results are obtained. Balancing, however, seems to be the most important of all adjustments on high-speed machinery, and the various problems encountered, especially in rebuilding old or damaged machinery, present problems of no ordinary calibre.

Perfect balance, speaking literally, is rarely or never encountered in real life, as it is an unnecessary, expensive and nearly impossible luxury. To illustrate, suppose a steel disk, 3 ft. in diameter, is fitted with a shaft, and each end of the shaft supported on a surface that is level and polished, so it will roll easily. The heavy side of the disk will then roll to the bottom, and it is easy to add or subtract weight, until the disc is apparently in perfect balance. This is only "apparently," however, because we have simply adjusted the balance so that the unbalanced turning force is less than the friction of rolling. Now, if the shaft is mounted on rollers of large diameter, so that the friction of rolling is greatly reduced, a heavier side can then be located at the bottom. To adjust this small amount of unbalance would be a delicate and more tedious job than the former operation and at the end we would

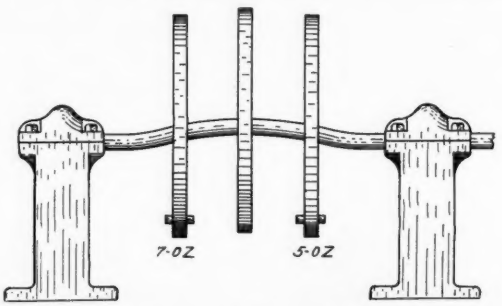


FIG. 2. DIAGRAM SHOWING LOCATION OF WEIGHTS AND SPRING OF SHAFT, EXAGGERATED

not be sure of perfect balance, as there still was friction of rolling, although very small. We can readily see some of the difficulties in the way of perfect balance, and why perfect balance would not be better practically than a very good balance.

The above method of balancing is called a "static," or stationary balance. This is often corrected further by a "dynamic," or moving balance. One method of moving balance is to suspend the assembled parts by a cable and rotate at high speed. The shaft is marked for running out, and weights are then adjusted, until it runs true. Another method is to bring the rotating element up to speed in its own bearings, and note the vibration, if any. If necessary to improve operation, weights are then adjusted. After much wrestling with the subject, the writer believes the latter method of running balance to be far superior to the former, where conditions make it possible. This is discussed more fully in its relation to critical speed.

Critical speed has been described mathematically and otherwise on many occasions. Designers have a distinct aversion for this unwelcome speed, and try to evade it by an ample margin. It sometimes may cause annoyance to the operating engineer, but the writer believes that such cases are extremely few and far between.

The theoretical critical speed, as computed by designers, is that speed at which the rotating element will

most readily vibrate. Each wheel has a natural period of vibration of its own, as also has the shaft, bearing pillow blocks, wheel casing, foundations and other parts of the set. The assembled rotating element, taken together, has a natural period of its own, that can be calculated with some degree of accuracy. The designer tries to place this speed a large step above normal, or below normal speed, or at least such a distance away that unbalanced condition will not easily set up sympathetic vibrations in the rotor.

The so-called "critical speed," as most operating engineers use the expression, refers to a speed below normal, where a distinct vibration can be felt, as the turbine is brought up to full speed, where it may operate very well. Sometimes vibration will take place at two or more low speeds, although the set would run perfectly at full speed.

If the machine is hypersensitive, it is reasonable to expect vibration at the critical speed; but if the tendency to sympathetic vibration is not excessive, then adjustments of line-up and balance may be so good

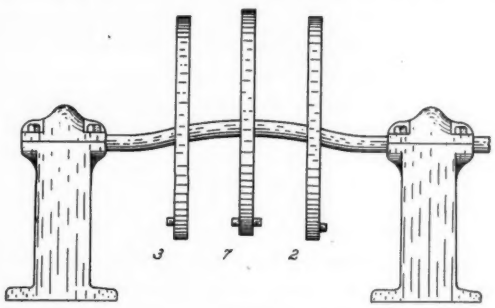


FIG. 3. FIRST ATTEMPT TO CORRECT CONDITIONS SHOWN IN FIG. 2

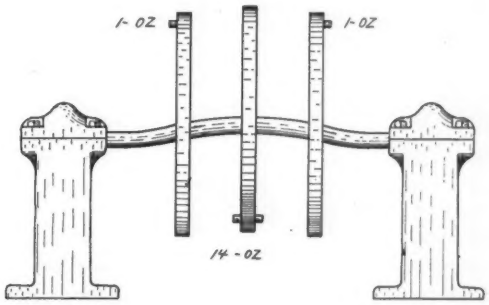


FIG. 4. SUCCESSFUL SOLUTION TO CONDITIONS SHOWN IN FIG. 2

that the machine will pass through it without perceptible vibration. The critical speed, proper, cannot be classed as a cause of vibration, but rather as a speed in which vibration is magnified.

Sometimes the operating engineer is right in saying that his machine has a critical speed where it always vibrates before reaching normal speed; but in most cases the vibration is not due to the critical speed, but is caused by shaft conditions or position of balance weights, etc., and is not anywhere near the real critical speed. Many machines of the same identical build would in all probability not show any vibration at this speed, while others would show vibration at a higher or lower speed. This is generally the case with a lot of turbine sets built exactly alike. This may be regarded as a minor critical speed, or as a vibrating speed, but very seldom is the critical speed of the set.

The writer has practically always been able to eliminate this minor or apparent critical speed by more accurate balancing; this was particularly noticeable in Case 8, described later.

A steel shaft is not homogeneous when we consider the matter closely. In the process of forging and cooling, strains are often introduced internally, and besides, when we examine the grain with a microscope or acid, it is not always alike in structure. As a shaft in the machine must lie with a deflection in the middle, and run a thousand or more r.p.m. in this curved position, it is reasonable to expect a vibration to be set up by the stiffer side of the shaft as it alternates between top and bottom. This non-homogeneous effect is further increased by the insertion of the keys and structure of the wheel hubs. It is therefore apparent why a rotating balance at full speed is sometimes necessary, even though the disks or wheels were in first class balance before assembling. The advantages of a running balance in the machines own bearings at full speed is apparent. When the shafts are made small and flexible, however the non-homogeneous effect is not so pronounced as in stiff shafts.

Case 5. A 1000-kw., 3600-r.p.m. turbine generator set was clearly out of balance as indicated by its operation at no load, which showed a continuous vibration of unvarying character and high periodicity at no load. It was not easy to tell which end was to blame, owing to the compactness of the unit. The coupling was separated, and the turbine tried by itself, which gave good operation. The field was then connected up and carefully balanced at normal speed. The unit then operated very satisfactorily.

Case 6. A small turbine on a steamship was found to give rough operation a short time after being installed, although the operation was first-class when installed originally. The evenness and periodicity of the shake showed that unbalance was the cause, and an investigation located this in the turbine end. An inspection of the wheels revealed that the balance weights had been eroded or eaten away by the action of acid in the steam. The machine was then rebalanced, and the weights were placed inside the wheels, which were of the double disk type, and no more trouble appeared. It is also practicable to use weights of acid resisting bronze, fastened with screws of the same material. Such cases often appear in machine practice where water is distilled from salt water.

Turbine sets that have been shut down several months with all valves closed, so that water collected in wheel casing, allowing wheels to rust on one side, have been put out of balance. Sediment or mud coming over in the steam, seldom causes unbalance, as the tendency is to leave little or none on the wheels, or else to distribute an even coating that is fairly well balanced in itself. This is especially true of centrifugal fans used in

vacuum ash hoist systems, where a heavy film of ashes is nearly always on the fan. Dirt sometimes causes vibration by collecting on high-speed generators.

Case 7. A small turbine with the armature and 2 wheels on a single shaft and 2 bearings as shown in sketch Fig. 1, had been rebalanced, but shortly after it developed severe vibration. Part of the time the machine appeared to be in good balance; but at other times, especially in cold weather, vibration was very bad. The shake was hard to identify, being so severe. From the variable symptoms it looked like bad shaft alinement; but as there were only 2 bearings, the bearing alinement was evidently not to blame, and besides, the wheel casing was lined up O. K. The wheels were dismantled and found to be tight on the shaft. The armature was brought up to speed as a motor, and found to be so badly out of balance as to be dangerous. The keyways in the shaft of course had been filled with metal, so they would not produce out of balance, as the normal speed was about 2000 r.p.m.

It was then seen that in balancing this turbine, the weights had been placed in the armature and wheels so as to pull against each other, and produce an excessive pull on the middle bearing. This is illustrated in the sketch, Fig. 1. Weight in the wheels at W pulled in the direction indicated by the arrow. This caused the armature to throw out as shown by the arrow at A. This was counteracted by placing armature weights at B, which really put the rotating element in good balance, but introduced a bad pull through the middle bearing, as these weights both pulled in direction of arrows W and B. The pull through the middle bearing is what really caused the vibration.

The armature was given a good running balance at full speed, and the wheels were assembled and balanced, one at a time. The general operation was then practically perfect and has remained so.

This matter of balancing a turbine set by introducing a pull through the bearing is often resorted to, either on purpose or by accident. The writer firmly believes that it is well worth the trouble to balance one rotating piece at a time, or else balance the turbine and generator ends separately, unless only a small amount of balancing is necessary as in machines when first received from the factory.

Case 8. A 150-kw. 3-stage machine gave great vibration trouble. A bad critical or vibrating speed was especially noticeable. The generator end ran O. K., leaving the turbine end responsible. The turbine shaft had a bad spring, but it was desired to make this run O. K. if possible to save the expense of a new shaft, provided that really good operation could be obtained. After much careful balancing on the turbine rotor, on the first and third stage wheels, as is customary, results were far from satisfactory. The relations of the spring in shaft and weights employed are illustrated approximately in Fig. 2.

In order to get better results, a weight in the second stage wheel was tried, opposite to the spring, and the other 2 wheels again balanced. Resulting weights were like Fig. 3, and operation was improved 100 per cent. The theory now appeared to be that weights in 2 wheels would not eliminate the spring without pulling so hard as to put the rotor out of balance, and weight in 3 wheels was better but not good enough. The next step was then to put an excessive weight in the middle wheel, opposite to the spring, and rebalance with weights on first and third wheels on same side as spring. This was accomplished as indicated in Fig. 4, and the resulting operation was very good indeed. The vibrating speed entirely disappeared, and machine could be brought all the way up to normal speed practically without vibration. This saved the expense of an entirely new shaft.

Couplings are sometimes thrown out of balance by using bolts of different lengths. Unbalanced governors and minor rotating parts seldom affect the general operation, affecting only local conditions. Castings of uneven character are often to blame. The usual remedy is to drill and tap equally spaced holes, and insert plugs in different places until the right position and amount is obtained. Marking shafts is seldom of much help, except in starting or in the case of low speeds, of 500 r.p.m. or so. All balance weights should be locked in 2 or more places. (To be continued.)

How to Extinguish Electric Fires

IN THE extinguishing of electrical fires there is large opportunity for the display of good judgment and prompt action," says H. L. Gannett, Inspector of Safety and Fire Protection, Commonwealth Edison Company, in discussing methods of fire prevention in the electrical station. "The element of time is exceedingly important. The operator should observe whether conditions warrant the cutting off of current from affected part before the fire is attacked. His knowledge of the apparatus under his charge should be such as to guide him promptly. Personal safety would discourage the use of hose line or some liquid chemical streams on apparatus in operations, or live current-carrying conductors.

"Sand and powdered bicarbonate of soda have been found to have some merit as extinguishing agents in certain kinds of electrical fires, but their use is limited.

"Where sand is provided for fire-extinguishing purposes, it should be carefully sifted through a sieve of window screen of 14 mesh to remove the larger particles, especially scraps of metal. It should be kept in a clean and dry condition and should not be used where there is a liability of its getting into the bearings of moving parts.

"In tests recently made in extinguishing oil fires, wet sawdust impregnated with sal ammoniac has been found to have considerable merit.

"Carbon tetrachloride has shown up well as an extinguishing fluid and has the advantage of being a non-conductor to a high degree, which is a very valuable attribute.

In many modern plants the liability of structural fires is vastly less than the liability of the occurrence of fire in apparatus, and much of this apparatus is so constructed that in case of fire occurring in the interior it is very difficult or impossible to use an extinguishing agent with success. Then, again, many fires in apparatus and conductors flash and quickly burn out, affording no time nor necessity for action."

Feed Water Control

Advantages of Automatic Feed Water Regulation and Description of Modern Controlling Appliances

In the early operation of high-pressure boilers, little attenton was paid to the exact water level. With the introduction of better engines, however, came the necessity of keeping the water within a certain high limit to prevent the formation of slugs of water which often wrecked the engines. To prevent priming due to a high water level and to avoid burning of the boiler as a result of low water naturally resulted in the establishment of a mean water level. To maintain the water level within restricted limits demanded more constant attention from the operator, and subsequently the apparatus for automatically maintaining the proper level was developed.

Automatic feed water regulation contributes much to the economical production of steam because it controls the proper supply of water to each boiler in proportion to the amount of steam generated without relying on the human personal equation. No matter how conscientious a fireman or water tender may be in the discharge of his duties, he is human, consequently subject to all the shortcomings of the human race, and is liable at times to overlook unintentionally some of his duties. Frequently the fluctuation of load on steam plants is so rapid that it is impossible to control the water supply by hand as accurately as if it were accomplished automatically. In large plants it is common to see the water level fluctuate from 2 to 6 in., as well as being high in some boilers and low in others. In small plants, where the fireman is solely responsible for water levels, the conditions may be equally bad, due to the fireman's attention being divided between water levels and other duties. Under normal operating conditions, a good feed water regulator is able to maintain a level within from ¼ to 1 in. of the desired mark.

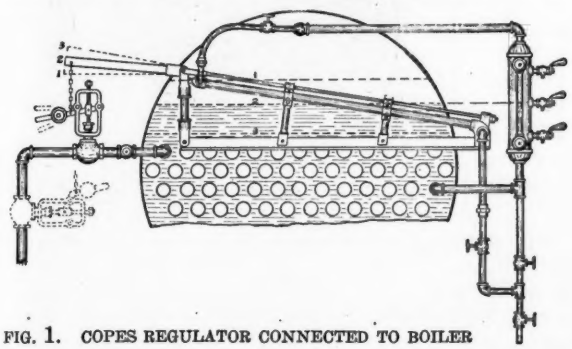


FIG. 1. COPES REGULATOR CONNECTED TO BOILER

Some regulators are designed not to maintain a constant level, but to lower the water level at heavy loads and raise it at light loads, the variation in height being adjusted according to local conditions. By this method little or no water is fed to the boiler during the approach of a heavy load, thus allowing all the available heat to be utilized in the generation of steam.

Whenever the design of the regulator is such that there is a possibility of sediment collecting, it should be inspected occasionally and cleaned, if necessary, to ensure reliable operation.

Copes Submerged Tube Regulator

This regulator, made by the Erie Pump & Equipment Co., of Erie, Pa., depends for its operation upon the expansion and contraction of an inclined tube, operating, through a system of levers, a valve which controls the flow of water to the boiler. As illustrated, this inclined tube is so placed that when the water in the boiler is at its lowest level, the tube contains steam, and as the water gradually rises in the boiler, it rises in the tube also. When the level of the water is as shown,

FIG. 2. THE "S-C" FEED WATER REGULATOR

part of the tube is filled with steam and is at the temperature of the steam, while that part of the tube containing water is at a lower temperature.

When an increased load comes on, there is a slight drop in steam pressure, accompanied by a more rapid liberation of steam from the entire body of water within the boiler, causing a corresponding increase in its volume and a rise in the boiler water level. This at once raises the level of the water in the expansion tube slightly, increases the amount of the tube submerged in the water and decreases the tube temperature, causing it to shorten. As this tube is connected by a simple system of levers to a balanced valve in the feed line, shortening of the tube causes the valve to close, so that increase in the boiler load by causing the rise in water level, results in a decrease in the rate of feed. This is the action desired in this type of regulator to obtain the maximum capacity of the boiler, since the heat being generated in the furnace is used to generate steam, and not to heat the feed water at a time when more steam is needed.

As the heavy load continues, the evaporation of water causes the level to drop with a consequent expansion of the tube and gradual opening of the feed valve until a point is reached where the rate of feed equals the rate of evaporation and equilibrium is restored, the water being at a new level.

Suppose as before that the boiler load is about normal and the water level is at middle gage. A decrease in load means a smaller steam demand, and a rise in boiler pressure, causing the fireman to decrease his draft, which results in a smaller generation of steam and a slight dropping of the water level with an accompanying heating up and expansion of the tube. This immediately causes the feed valve to open wider and feed the water at a higher rate, thus absorbing and storing heat which

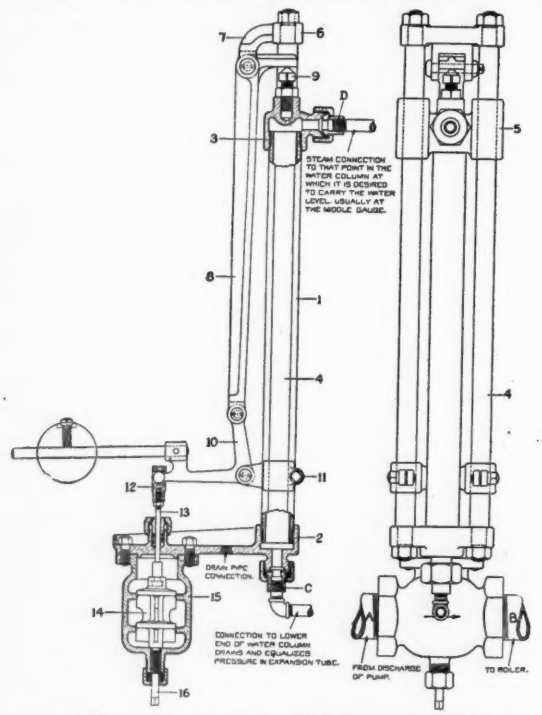

STEAM CONNECTION TO THAT POINT IN THE WATER COLUMN AT WHICH IT IS DESIRED TO CARRY THE WATER LEVEL, USUALLY AT THE MIDDLE GAUGE.
DRAIN PIPE CONNECTION.
CONNECTION TO LOWER END OF WATER COLUMN DRAINS AND EQUALIZES PRESSURE IN EXPANSION TUBE.
FROM DISCHARGE OF PUMP.
TO BOILER.

FIG. 3. DETAIL VIEW OF FOSTER REGULATOR

the furnace would otherwise waste. The rising water cools the expansion tube and slowly cuts down the feed again so that at any fixed load position the rate of feed becomes just equal to the rate of evaporation.

The "S-C" Feed Water Regulator

As shown in the accompanying illustration, this regulator consists of a generator surrounded by a radiator, connected to the water column and so placed that the mean water level in the generator will correspond to the mean water level in the boiler. From the bottom of the generator a flexible tube leads to feed control valve.

The tube connecting the generator to the lower water column outlet is under boiler pressure and contains water up to the corresponding water level in the boiler, the portion above being filled with steam while the generator and flexible tubing up to the diaphragm of the control valve contain water. Water in the tube connecting the generator to the boiler is exposed to radiation through the fittings and is at a temperature below the boiling point, while the upper part of this tube, being filled with steam, is at a considerably higher temperature and as a result the hot part will have a tendency to boil the water in generator, creating a pressure which through the flexible tubing acts on the diaphragm of the control valve, causing this to open and admit water to the boiler. The rising water in the boiler and consequently in the connecting tube, together with the effect brought about by the radiator surrounding the generator, cools the water in the generator, reduces the pressure and

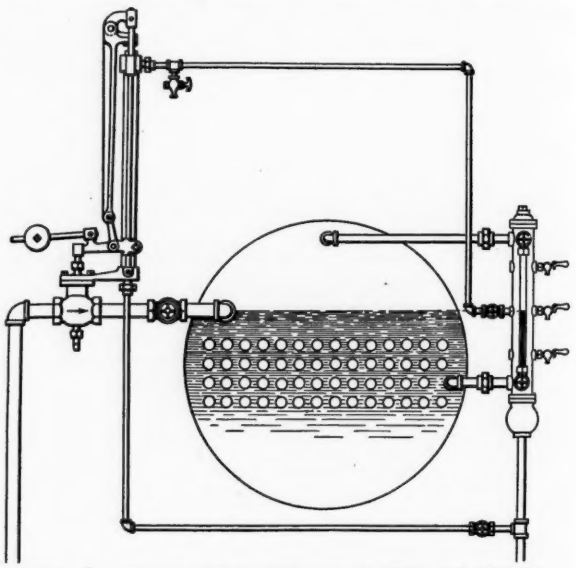


FIG. 4. FOSTER REGULATOR CONNECTED TO BOILER

as a result allows the control valve to close. The "S-C" Regulator Co., of Fostoria, O., makes this regulator.

Foster Feed Water Regulator

Expansion of a tube actuating the main feed valve is the operating principle of the automatic regulator made by the Foster Engineering Co., Newark, N. J., the details of which are shown in Fig. 3. Normally, the water in the boiler or water column seals the end of the pipe leading to the top of the expansion tube, so that the steam is excluded and the tube is cool and contracted. In this condition of the expansion tube, the long arm of the bell crank lever, 8, is free to swing outward from the expansion tube and allows the weight to depress the arm of the lower bell crank, 10, so as to slide valve, 14, downward into closed position, preventing water from entering boiler through the feed line.

When the water recedes below the predetermined boiler level, it uncovers the opening in the pipe leading from the water column to the top of the expansion tube and permits steam to enter the tube. This heat expands tube 1, fitted with the adjusting screw, 9, which may be set for any desired variation, upward against the short arm of the bell crank lever, 8, thus swinging the long arm of the crank inwards or towards the expansion tube. This carries the lower bell crank lever, 10, and raises the weight, drawing valve 14 upward, opening the main feed valve, and permitting water to flow into the boiler. (To be continued.)

Economy in the Use of Coal

FUNDAMENTALS IN THE COMBUSTION OF COAL; CAUSES OF HEAT LOSSES. BY A. BEMENT

SOME years ago, in a discussion of the matter of fuel economy, the following words were used. "If it could be generally realized that coal burning should be a scientific business, the result would be beneficial. But no one burns coal as a final object. The purpose of every industrial enterprise is the production of some commodity requiring an exact process, and each manufacturer realizes this in his special business, but practically all fail to consider coal burning as a matter requiring similar exact methods in its treatment."

Since this statement was made, there has been considerable advance along engineering lines, tending toward greater fuel economy; such advance, however, has concerned itself more particularly with the development of instruments of precision, by the use of which a comprehensive knowledge of the combustion process can be obtained, and which may also be employed as a guide in the operation of fires. The most important device of this character is the CO_2 recorder. In the past, we have gone through a period devoted to the development of the required appliances; we have now reached a stage in which every requisite for the attainment of fuel economy is available to any coal user, and the next step is the employment of the appliances now to be had.

The burning of fuel, the attainment of combustion, the management of fires, have been dealt with as an art, not as a matter of science recorded in books from which one may obtain instruction. The result has necessarily been that the matter was generally left to the judgment of the fireman, who followed a practice derived wholly from his own experience. The status of steam boiler practice is much behind that of the engine. That this is true will be apparent when it is considered that the engine has gone through several stages of development. It has been made condensing, its steam pressure raised, made compound, triple and quadruple expansion, superheated steam employed, redesigned in the form of the steam turbine, while there has been but slight fundamental change in boiler practice. In fact, no single improvement in boiler or furnace is equal to any one of those made in case of the engine.

In view of the greater complexity and difficulty of the problem of the engine, as compared with the boiler, it is indeed strange that this should be. It is true, however, that generations of students have been at work on the engine, and the best explanation of this is probably to be found in the fact that the problem of the engine is dealt with in the science of physics, which is a branch of engineering. Thus engineers have been qualified by training to deal with the engine in all of its phases, while on the other hand the boiler and furnace problems are involved with chemistry, which is a separate and distinct science from that of engineering, and with which engineers deal but little. It has not mattered that the chemical problems are extremely simple, and are no necessary obstacle, but pertaining to a different branch of science, they presented themselves nevertheless as formidable difficulties. The steam engine indicator is universally understood and used and the information obtained by it is readily applied.

With the CO_2 recorder, which is to the furnace what the indicator is to the engine, the case is different because thus far it has not received the consideration which it deserves and its importance justifies, and it is the main purpose of this paper to set forth the value and adaptability of this automatic CO_2 recorder.

If real success is to be attained in fuel economy, it is essential that the possibilities of improvement be examined in detail. In this connection 3 questions naturally arise, these questions are:

1. What saving is possible?
2. How do the losses occur?
3. How can these losses be prevented?

Answers to these question will occupy the following pages. The reply to the first involves a study of what is known as the heat balance, or in other words the disposition of the heat as it comes from the coal and it is the ideal or perfect performance with which we are concerned. This is shown in Table I and refers entirely to the combustion process. Inasmuch as the quality of the coal has a bearing on the matter, the process is shown with an average good and poor fuel. These calculations are upon the basis of 17 per cent CO_2 with gases going to the chimney at 550 deg. F. The maximum CO_2 is between 18.5 and 19.0, thus 17 allows for some excess air, sufficient for the condition represented.

In steam making, the heat which is not lost is necessarily usefully employed; thus, if the losses are known, it is then possible to determine what the efficiency will be. With the ideal condition shown, about 90 per cent of the loss goes to the chimney and the other 10 is practically all lost in heat radiated from the boiler and setting. No loss of fuel in the ashes, or, in other words, in the ashpit refuse, is shown, for two reasons: one is that this is not a loss having any connection with the combustion process, the other is that with an ideal practice all of the fuel would be burned and there would be none in the refuse.

TABLE I. SHOWING IDEAL DISTRIBUTION OF HEAT IN STEAM PRODUCTION.

		Percentage distribution of heat with variety in coal.	
		Good coal	Poor coal
1.	Loss in the dry, hot chimney gas	9.63	9.33
	Loss in the moist, hot chimney gases—		
2.	Due to the combustion of available hydrogen	3.50	3.00
3.	Due to the presence of water of combination in the coal	0.50	1.50
4.	Due to the presence of moisture in the coal	0.05	1.75
5.	Due to the presence of vapor in the air supply	0.25	0.24
6.	Loss by sensible heat in the ashes	0.07	0.18
7.	Loss by radiation from the boiler and its setting	1.50	1.50
	Total loss	15.50	17.50
8.	Heat available for making steam	84.50	82.50
	Total heat of the coal	100.00	100.00

Item No. 1 of the heat balance is the heat carried away by the CO_2 and the nitrogen from the air supply with a little oxygen. It is calculated upon the basis of 0.23 B.t.u. per pound of gas for each degree Fahrenheit rise in temperature. With Item No. 2 that portion of the hydrogen not already in combination with oxygen

which is in the coal unites with oxygen of the air supply forming H_2O or water which goes to the chimney as steam. The oxygen in the coal in combination with a portion of the hydrogen in the coal is thus already in the form of water, as shown in Item No. 3. Item No. 4, the moisture in the coal is in the form of water. Thus Items 2 to 4, inclusive, are in the nature of water and must first have their temperatures raised from that of the atmosphere to 212 deg., requiring one B.t.u. per pound for each degree rise in temperature, then the water must be evaporated, requiring 970.4 B.t.u. per pound, after which the resulting steam is superheated to the temperature of the chimney. The figure representing loss due to vapor in the air supply is a constant generally employed to represent this loss.

Item No. 6 is always a small loss; it represents the heat necessary to elevate the temperature of the ashes from the atmosphere to that at which they enter the ash pit. The foregoing losses are well understood by those who are familiar with the details of the combustion process. Item No. 7, however, is one which has caused much trouble due to the absence of exact knowledge regarding its magnitude. The opinions which have largely prevailed have been derived from an unaccounted for loss in the heat balance, due principally to incomplete combustion in the form of escaping hydrocarbons, the presence of which was unsuspected on account of there having been no method of analysis for their direct determination, with the result that quite generally radiation has been much overestimated, and the possibilities of efficient combustion greatly obscured. Some years ago, R. S. Hale, after an extended analysis of many boiler tests, concluded that the radiation loss with boilers worked at rated capacity, was 1 per cent. Since that time, other careful tests* indicate that unaccounted for loss and radiation are at least as low as 2 per cent. When the fact is taken into consideration that a portion of this 2 per cent was incomplete combustion, together with Mr. Hale's conclusion, the radiation value of 1.5 per cent is justified.

From the foregoing, as shown in Table I, efficiency with good coal appears as 84.5 and with poor coal 82.5, averaging 83.5 per cent. This represents not what is often or ever attained in practice under present conditions; but it does show the capability of the process, and gives us a standard by which we may consider the possibilities of fuel economy in steam production. Thus, if the efficiency now obtained in any particular case be known, comparison with this standard will show the range susceptible of improvement. In a general way, what this means may be determined if the average efficiency be known; it is my experience that general operating efficiency is below 55 per cent, but for conservatism it will be assumed that it is that much. The difference between this figure and the standard of 83.5 is 28.5 per cent. What the attainment of this possibility would mean in economy, with coal at different prices, is shown in the Practical Reference Tables of this issue.

Before an evil can be corrected, it must be understood, and while the object of this paper is to deal with the combustion process, there is one other fuel loss which does not belong to Table No. 1, and to which attention should be directed. It is the fuel which drops through the grate or in other manner gets into the ashes; it is loss that is often overestimated. Another chart is given which will be useful as showing a range of such losses. The figures of the vertical scale represent ash in the coal that is used, and the horizontal figures, fuel loss in per cent for different amounts of coal in the refuse. The amounts of fuel in the refuse are indicated by the radial lines of the diagram in steps of 10 per cent up to 60 per cent.

To employ this diagram, it is necessary to have an analysis of the coal and refuse, or, in other words, to know what these proportions are. The significance of the matter, however, may readily be grasped without a definite knowledge of such figures. For illustration, assuming ash in the coal at 7 per cent and combustible in the refuse at 20 per cent, reading on the horizontal line of the ash content to its intersection with the 20 per cent refuse line, then downward to the bottom of the diagram, it appears that fuel loss is 1.8 per cent. Fuel in the refuse is usually not in excess of 20 per cent, and ash in the coal usually not below 5 per cent; this means that fuel loss of this character would range generally between 1.25 and 3.25 per cent.

(To be continued.)

*Transactions, American Society of Mechanical Engineers, Vol. 33, Pages 624 to 627 and 637.

Ten Things to Do

1. Use cocks especially designed for air, on gasoline, kerosene and other light oil lines.
2. Use approved material on piping equipment subject to underwriter inspection.
3. Use regrinding globe valves where frequent operations are necessary.
4. Insist that all nipples are chamfered, reamed and true to gage.
5. Cut threads on pipe for use on railings, so that when job is finished, no threads will show.
6. Avoid the use of special railing fittings requiring new patterns.
7. On power piping where screwed flanges are used, have face of flange and end of pipe flush and smooth.
8. Use sight feed type of lubricators and oil cups.
9. Use hydro-pneumatic water relief valves on hot water tanks.
10. Use blowoff valves on skimmer lines.

—Valve World.

THE OHIO BOARD OF BOILER RULES at a special meeting held Dec. 21, 1916, unanimously adopted the American Society of Mechanical Engineers' Boiler Code, insofar as it relates to the construction and installation of new boilers, these rules to take effect July 1, 1917.

This is in accordance with the resolutions adopted at the American Uniform Boiler Code Congress held at Washington, D. C., Dec. 4, 5 and 6, 1916.

U. S. CIVIL SERVICE COMMISSION announces an examination for laboratorian, qualified in electrical science, on Feb. 7, to fill a vacancy at $3.60 a day in the machinery division of the Navy Yard, Mare Island, Cal. Applicants must have reached their twentieth birthday. Apply for Form 1312.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Factory Fire-Alarm Systems

DESCRIPTIONS OF EQUIPMENTS READILY CONSTRUCTED AND INSTALLED BY ANY ENGINEER. BY J. C. HAWKINS

IN nearly all manufacturing plants there is need of some type of alarm system by means of which employes and members of the institution's fire department may be notified in case of fire. In some cases, these alarms are sounded on a gong; but in a plant of considerable size, the factory whistle may be used instead.

Two electrically-operated alarm systems which may be used successfully and which differ in detail only, are shown diagrammatically in Figs. 1 and 2. The whistle is blown by steam, the valve being operated by a solenoid taking current from a 110 or 220-v. direct-current circuit through a relay. When the contacts of the relay are closed, the current flows through the solenoid, drawing the armature down and opening the whistle valve. When the relay circuit is opened, the armature of the solenoid, assisted by the spring, comes back to its original position and the valve closes.

The system may be arranged on either the open- or closed-circuit principle. Figure 1 shows the latter arranged in the following manner: A number of alarm stations are located about the plant and grounds, connected in series with each other, a set of batteries and the relay. Each station may consist simply of a single-pole switch placed in a weather-proof box if outdoors, or a regular fire alarm box of which there are many designs, the location and size of the system determining the proper type to use. In case a regular fire alarm box is employed, it is only necessary to open the door and pull the lever, or break the glass, which will sound the alarm in proper order. If a single-pole switch is used, it is necessary to open and close the switch for each whistle blast.

When in its normal position with the signal circuit closed, current from the battery flows through the circuit, causing the magnet of the relay to hold up its armature and the main contacts open. If the circuit is broken at any box, the weight on the lever of the relay pulls the armature away from the magnet and closes the contacts of the main circuit which operates the solenoid and blows the whistle until the circuit is again closed, the circuit being opened as many times as blasts of the whistle are desired. Each box is given a separate number, thus informing the men detailed for fire duty from just what part of the works the alarm came.

The circuit may also be extended to the office, not only for the purpose of sounding an alarm, but also for blowing the whistle to announce working hours.

Figure 2 shows the open-circuit system which has the whistle valve operated through a relay in about the same manner as in the closed-circuit arrangement except that the contacts of the relay are normally held open by the armature weight and closed only when the current is established in the battery circuit at any box. This causes the relay magnets to draw up the armature and close the contacts of the main circuit blowing the

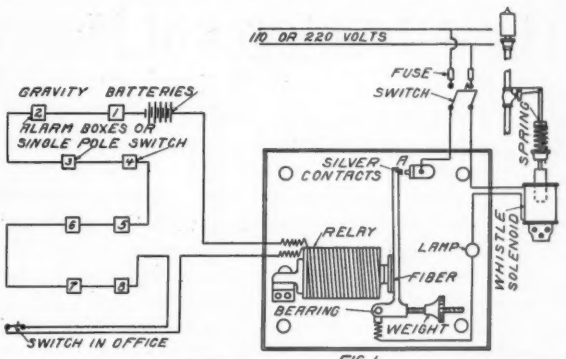


FIG. 1

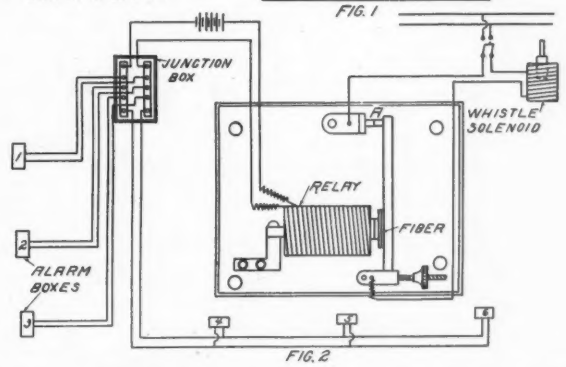


FIG. 2

FIG. 1. SCHEME OF CONNECTIONS, CLOSED-CIRCUIT FIRE ALARM SYSTEM

FIG. 2. SCHEME OF CONNECTIONS, OPEN-CIRCUIT FIRE-ALARM SYSTEM

whistle until the circuit is again opened. The several circuits are wired to a junction box from which the current passes through the batteries and relay magnet.

This system has the advantage that where the stations are far apart wire may be saved and 2 or more boxes may be placed in parallel across one line if desired. It is not recommended that ground returns be used as

metallic returns are more reliable and less apt to give trouble. Unless the system is in daily use, as it would be for blowing the whistle for working hours, it should be tested every day, if the open-circuit system is used, for the reason that, should the battery become exhausted or the line break, it would not be known until a fire occurred. If the closed-circuit system is used, should the batteries become weak or the line break, the whistle would blow until the main switch was open, thus notifying the engineer at once that the system was out of order. For the closed-circuit system, gravity (crowfoot) batteries are employed; a standard open-circuit battery must be used on open-circuit system as gravity batteries would be damaged through sulphating.

The main whistle valve and solenoid may be purchased from several different companies making valves, and will operate on direct current only. If this is not available, a motor-generator set and small storage battery outfit or a gravity-operated whistle-blowing machine, of which there are several on the market, will be necessary. The closed-circuit system shown in Fig. 1, is suitable for a small town having its own electric light plant with the plant whistle used to sound the alarm.

In this case, standard village fire alarm boxes are employed, located at various parts of the town.

For a village, it is best to dispense with the solenoid-operated valve, as there is a possibility of the operating current being off when an alarm is turned in. Central station current coming through one or more substations is unreliable and should not be used. If, however, there is a local plant running 24 hr. a day, or one in which somebody is on duty at all times, the electrically-operated whistle may be employed. In the gravity trip whistle machine, the relay simply trips the machine and the whistle is blown by the falling of a weight.

Where a large number of boxes are used, numbers of 2 or more figures are necessary and the alarm is blown as follows. Number 35, - - - - - - - - -; number 45, - - - - - - - - -; etc.

In the town in which I live there is no steam boiler, the water works being operated by gas engines, and a compressed-air system was installed. This operates in exactly the same manner as a steam alarm, except that the air is taken from a storage tank automatically supplied by a motor-driven compressor.

The Advantages of Modern Types of D-C Machines*

CAUSES WHICH LEAD TO THE DEVELOPMENT OF COMMUTATING POLES AND COMPENSATING WINDINGS. BY DAVID HALL

WITH commutating poles and compensating windings, and the necessary field connections, the modern type of direct-current machine presents certain complications as compared with the plain non-commutating pole machine. The user of such a machine naturally asks: "Why the additional complication; what am I getting in the modern type machine that I did not get in the old type; is the machine any cheaper, or does it perform any better; what can be accomplished with the modern design that was impossible with the old design?"

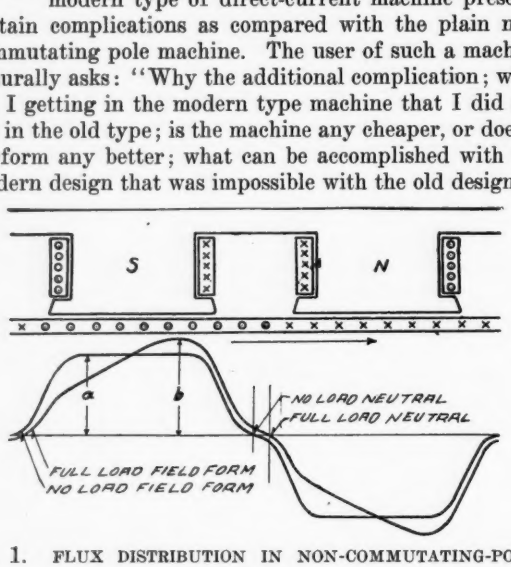


FIG. 1. FLUX DISTRIBUTION IN NON-COMMUTATING-POLE GENERATOR

In considering the output of a rotating electrical machine, flux capacity and ampere wire capacity are 2 important factors.

Output = Flux × Amperes × Wires × Speed × a Constant.

Increasing the length of a given armature increases the flux capacity, but it does not increase the ampere wire capacity. Hence, the output of the armature will increase directly with its length. Increasing the diameter of an armature increases both the flux capacity and the ampere wire capacity. Hence, the output of an armature increases directly with the square of the diameter. Combining these 2 statements, we conclude that the output of a given armature is proportional to the square of its diameter multiplied by its length.

Output is proportional to $D^2 L$, where D = diameter of the armature in inches and L = length of armature in inches.

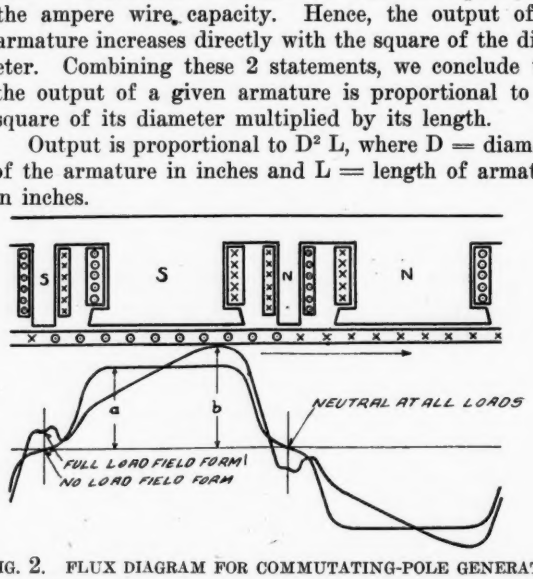


FIG. 2. FLUX DIAGRAM FOR COMMUTATING-POLE GENERATOR

Kw. = $D^2 \times L \times$ r.p.m. × output factor.

It may be of interest to analyze the above formula a little more closely, and see on what the output factor depends. The following proof will show that this output factor represents what may be called the loading factor of the armature, or, in other words, the magnetic flux per inch of length, and the armature ampere wires per inch of armature diameter.

Let F = number of lines of flux per inch of diameter per inch of length of armature.

*From a paper read before the Association of Iron and Steel Electrical Engineers.

A = Armature ampere wires per inch of armature diameter.

Total flux = F × D × L.

As the cutting of 10^8 magnetic lines per second by one conductor generates one volt, and as each conductor or wire on the armature cuts the total air gap flux once in one revolution, the expression for the voltage generated is:

$$\text{Volts} = \frac{F \times D \times L}{10^8} \times \frac{\text{r.p.m.}}{60} \times \frac{\text{Wires}}{\text{Circuits}}$$

Multiplying both sides of the above equation by amperes, we obtain:

$$\text{Volts} \times \text{Amp.} = \frac{F \times D \times L}{10^8} \times \frac{\text{r.p.m.}}{60} \times \frac{\text{Wires}}{\text{Circuits}} \times \text{Amp. per wire} \times \text{Circuits.}$$

$$= \frac{F \times D \times L}{10^8} \times \frac{\text{r.p.m.}}{60} \times \text{Amp. Wires.}$$

$$= \frac{F \times D \times L}{10^8} \times \frac{\text{r.p.m.}}{60} \times A \times D.$$

$$= D^2 \times L \times \text{r.p.m.} \times \frac{(F \times A)}{(60 \times 10^8)}$$

In this equation we have an expression for the total watts of the machine. The term in the parentheses is the output factor. The output which is obtainable from a given size armature at a given speed depends upon the flux per inch and the ampere wires per inch. The higher these 2 factors are worked, the more will be the output from a given armature. These 2 factors have their limits. If the flux is too high a large amount of field copper is required, at a consequent increase in cost. Also, if the flux density in the armature teeth and core is made high, the iron loss will be high.

Armatures with narrow deep slots have more self-induction due to current reversal than armatures with wide shallow slots, and while the capacity of such armatures from the heating standpoint, as shown by our formulas, may be very large, the commutation limit might be much lower. The above formulas have in no way taken commutation into consideration, and if there is any one element in a direct-current machine which is more important than all other elements, it is commutation. We thus arrive at the real reason for adopting some special means for taking care of commutation.

Necessity for machines with greater overload capacity, for machines of high speed, for wide range, variable speed motors, for generators capable of operating over a wide range of voltage, for machines which would stand reversal, either mechanically, electrically, or both, has led to the general introduction of special means for insuring good commutation.

No fixed neutral position for the brushes existed on the old non-commutating-pole machine. The generator required that the brushes be moved forward, the motor required that the brushes be moved backward. The amount of brush shift was dependent on the load, consequently, many non-commutating-pole machines cannot be satisfactorily operated through a wide range of load without changing the brush position.

Reversing motors for large blooming mills, some of which today carry swings of more than 10,000 amp. at 1200 v. would be impossible without special provisions for commutation. High speed generators supplying energy to such reversing motors would not have been considered under the old type of design. The motors for speed variations of 4 to 1, and generators, which will commutate throughout the entire range of voltage have widened the field of application of electrical machinery. These are not all the advantages, for, with good inherent commutation, graphite brushes can be used, as a high brush contact resistance is not necessary. Such brushes have a low coefficient of friction, and they do not wear the commutators as the old carbon brushes did. Both the life of the commutator and the life of the brushes are greatly lengthened.

Types of Construction

Two general types of field construction are being used in d.c. machines. One type using commutating poles and the other type, which is a variation of the commutating pole type which is called a compensated machine.'' The commutating pole machine is made

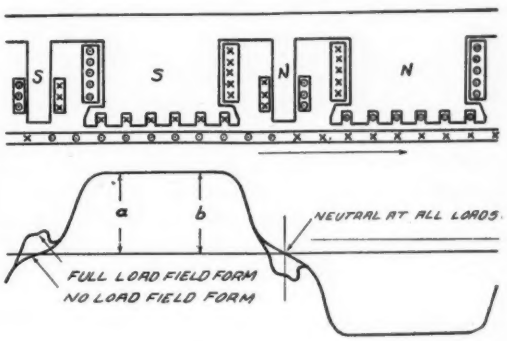


FIG. 3. FLUX DIAGRAM FOR GENERATOR WITH COMPENSATING WINDING

by introducing additional small poles between the main poles. The small poles are magnetized by a winding which is in series with the armature, and the brushes are so placed that the coil during commutation comes under the influence of the flux from the commutating poles, which flux is of such value and direction that cutting it produces in the coil undergoing commutation, a voltage which neutralizes the voltage of self induction. In a generator, the flux from the commutating pole must be in the same direction as the flux from the main pole immediately ahead and in a motor, the flux from the commutating pole must be in the same direction as the flux from the main pole immediately behind. An easy way of remembering this relation is to consider that in a generator, a piece of the main pole is moved *backward,* instead of the brushes being shifted *forward,* and in a motor, a piece of the main pole is moved *forward,* instead of shifting the brushes *backward.*

This brings the neutral position midway between the main pole pieces, for either a motor or a generator, and by connecting the commutating pole winding in series with the armature, a change from generating load to motor load automatically changes the polarity of the commutating poles. Thus, such a machine is suitable

for either motor or generator operation, without any movement of the brushes. This characteristic is important and has opened a wide field of application, which could not be covered by the older type of machines.

The next principal variation from the commutating pole machine, is the compensated machine; in fact, a compensated machine may be looked upon as a modified commutating pole machine. The commutating pole machine has the exciting winding concentrated about the commutating pole, while the compensated machine has a part of the exciting winding distributed in the main pole face. The total excitation is the same in both cases. See illustrations, Figs. 1, 2 and 3, of the directions of the currents in the non-commutating pole machine, the commutating pole machine and the compensated machine.

As the commutating pole machine is simpler in mechanical construction than the compensated machine, the question naturally arises as to why the latter construction is used. In order to explain this, it is necessary to consider the function of the commutating pole winding. Figures 4 and 5 show the magneto-motive forces, which are present in both types of machines.

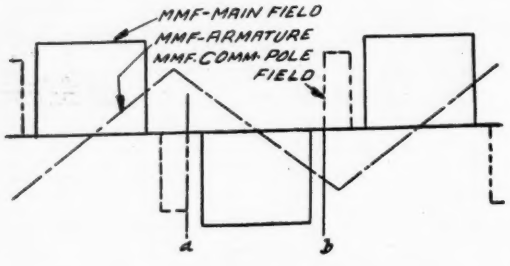


FIG. 4. MAGNETO-MOTIVE FORCES IN COMMUTATING-POLE GENERATOR

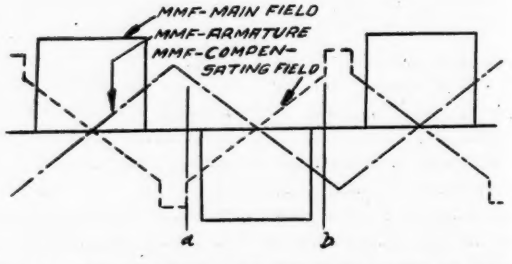


FIG. 5. NEUTRALIZED ARMATURE REACTION IN COMPENSATED GENERATOR

The essential difference, as will be noticed from an inspection of the diagram, is that in the commutating pole machine, the armature reaction is not neutralized in the zone "a-b," while on the compensated pole machine the armature reaction is completely neutralized under the main pole. In order to maintain the best commutating condition, the flux from the commutating pole must change in exact proportion to the change of load. As soon as there is any saturation in the commutating pole, this exact relation is destroyed and the commutation limit is soon reached. It is, therefore, undesirable to use shunts around either the commutating pole winding or the compensating winding, as the presence of shunts may destroy the straight line relations between the armature current and the exciting current which produces the commutating flux.

As the commutating pole must carry both the useful flux or commutation and also any leakage flux which may be produced by its winding, it is evident that reducing the leakage flux will increase the commutation limit of the machine. The most effeetive way of reducing this leakage flux is to distribute the commutating pole exciting field winding in the main pole faces and thereby increase the length of the path of leakage flux. This construction becomes what we have called the compensated machine and it possesses two distinct advantages over the plain commutating pole machine. It has a greater maximum commutating capacity and as the armature cross-magnetization is neutralized under the main poles, the maximum voltage between adjacent commutator bars is correspondingly less. By taking advantage of these points, it becomes possible, by the aid of compensation, to increase the speed of generators and to make motors which will meet more difficult cycles of operation.

As has been shown in the compensated machine, there is no distortion of the main pole flux; consequently, a higher average voltage between commutator bars is permissible. That is, with the same peak voltage between commutator bars, the compensated machine can have a higher average voltage between bars than the commutating pole machine. Hence, for very high speeds, the compensated machine makes higher ratings possible. For the same reason, the compensated machine makes higher voltage machines, for a given speed, possible.

It is a fact that the compensated machine is not as easily dismantled and not as easily repaired as the commutating pole machine and for pure simplicity of construction and minimum numbers of parts, we must admit that the old non-commutating pole machine is superior to either of the later types. Hence the better performance is obtained at a sacrifice of simplicity and a universal application of compensated machines would be as much of an error as would be an attempt to apply non-commutating pole machine to all classes of service.

U. S. CIVIL SERVICE COMMISSION announces an examination, Feb. 6, for electrical draftsman, to fill several vacancies in this position in the Bureau of Yards and Docks, Navy Department, Washington, D. C., at salaries ranging from $3.52 to $6 a day, and vacancies as they may occur in position requiring similar qualifications in the Department at Washington or at any navy yard or other naval establishment of the United States. Competitors will not be required to report for examination at any place, but will be rated on education, preliminary traniing and experience. It is desirable that the drafting experience required be of an electrical character such as may be acquired in the electrical department of a public-service corporation or in a plant manufacturing electrical equipment, or in some U. S. naval establishment. Applicants must have reached their eighteenth birthday on the date of the examination. Apply for Form 1312.

Felling a Chimney

Narrow Limits Necessitate Extra Precautions. By H. K. Scholefeld

An iron chimney, 100 ft. high by 6 ft. diameter was situated between the battery of boilers to the left and the single boiler, B, Fig. 1. It was necessary to fell this chimney across the setting B, this direction being the only one where the stack would fall clear of machinery erected on several tiers of flooring. Beyond the partition, C, a 50-hp. upright marine engine drove a line shaft, supplying power to the machine shop. This engine and shop were situated on the ground floor with nothing overhead except a leanto roof. The problem of felling the chimney without moving this engine or lathe D, or injuring them or the boiler setting B, was carried out as follows.

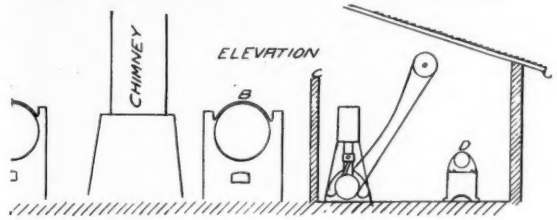


FIG. 1. PLAN AND ELEVATION SHOWING LOCATION OF CHIMNEY

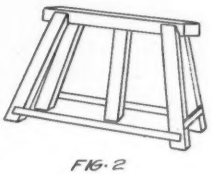
The length of shafting, shown between couplings, was taken down and the framework partition C was cut away. A large trestle, Fig. 2, was built of 10 by 12-in. timbers, in shape like a wooden horse with an extra leg. When erected this was 20 ft. high and 18 ft. long. The trestle was built directly over the engine as shown in Fig. 3.

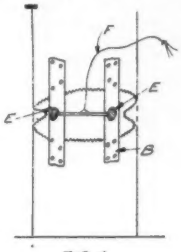
It will be seen that the falling chimney would strike the trestle before it came in contact with the boiler setting, thus expending the force of the fall in crushing the chimney on the trestle. The boiler would then have only to support the weight of stack lying between the trestle and stack foundation.

The lathe was protected by a crib of timbers piled over it as shown in Fig. 3, while some timbers placed upon the brickwork of the boiler prevented injury thereto. The roof was cut away from the chimney to wall E, Fig. 1, which was also cut open.

It was necessary to fell the stack accurately along the line of the arrow, Fig. 1, a variation of only about 10 deg. being possible without great damage to surrounding buildings and contents. To insure the proper direction being taken by the stack, the following measures were taken.

Two lines of holes were drilled ⅔ of the way around the bottom of the stack, as shown in the side view, Fig. 3, thus cutting away the part A, and leaving a V gap





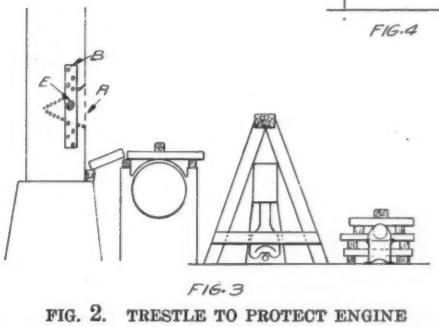


FIG. 2. TRESTLE TO PROTECT ENGINE
FIG. 3. STAGING TO PROTECT BOILER, ENGINE AND LATHE
FIG. 4. LOCATION OF DYNAMITE CHARGES

similar to the gash cut in a tree, when felled with an ax. Before cutting through the webs between these holes, 2 bars of 3 by 6-in. cast iron were bolted across the gap, shown at B, Figs. 3 and 4. These formed pillars to support the stack when the part A was removed. The stack would then be resting on 3 legs, 2 of cast iron and 1 of the original metal. Preparations were made to explode dynamite charges E against both cast-iron legs at once. We had to use fuses, as we had no electric

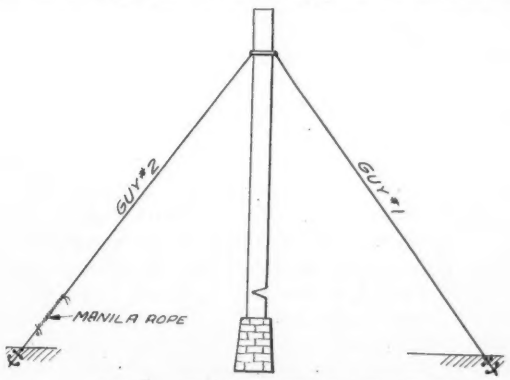


FIG. 5. ARRANGEMENT OF GUY WIRES

caps; but as fuses might not burn at an equal rate we connected the 2 charges together by filling a piece of ⅜-in pipe of suitable length with dynamite, and burying one end in each of the charges as shown.

A capped fuse F was inserted in a small hole drilled at the center of this pipe.

There remained the guy wires to manipulate. All guys were slacked off, and guy No. 1, Fig. 5, was carried around and anchored on the line of the arrow, Fig. 1.

Guy No. 2 was anchored directly opposite, to hold back against the falling stack. Into this holdback guy was spliced a short length of manila cable.

We now pulled on guy No. 1 till the stack was thrown out of plumb about 2 ft. Guy No. 2 was paid out carefully meanwhile, being kept taut at all times. We now placed an axman at No. 2 guy, instructing him to chop through the manila cable as soon as he heard the explosion.

It will be seen that the two supports having been blown up and the holdback guy cut, the stack was already well started on the way it should go. The top being 2 ft. out of plumb and the bottom removed all but a third, no wind to influence the matter, and with the direct pull of guy No. 1, which was no longer counterbalanced by No. 2, the proper direction of fall was assured.

Our calculations worked out exactly. Both charges exploded together, and a second later guy No. 2 flew into the air. The stack trembled, swayed, and surged over, falling exactly where we wanted it.

The effect of the trestle was peculiar. The stack was not crushed upon it as expected, but broke clear off at a joint 20 ft. from the gap. This section went spinning like a peg top, crashed into the brickwork of boiler B, and knocked out a dozen bricks from a corner.

The trestle stood the shock perfectly, and neither engine nor lathe was damaged a hair.

Gas Engine Testing

TYPES OF BRAKES; CALCULATIONS; RESULTS OF TESTS

IN the Gas Review, P. S. Rose states that engines are rated according to their brake horsepower; that is, according to the work they are actually able to deliver at the driving pulley. Steam engines are rated not only by this method, but also by their indicated horsepower as obtained by means of an indicator; but, while it is comparatively easy to indicate a steam engine, it is comparatively difficult to indicate a gas engine, and especially one running at a high speed.

All brakes work on exactly the same principle in that they absorb the power of the engine by frictional con-

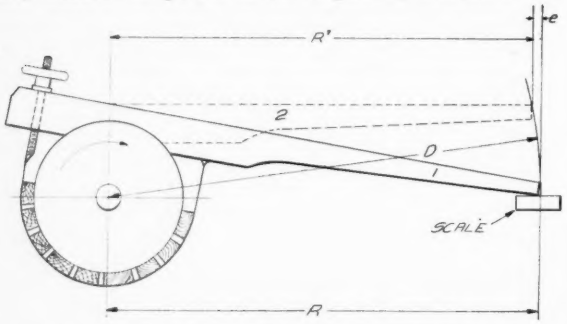


FIG. 1. TYPE OF BRAKE SUITABLE FOR TESTING SMALL ENGINES

tact. The force necessary to overcome the friction is weighed, and this, with the length of the brake arm and the number of revolutions of the pulley per minute, enables the investigator to determine the horsepower, the formula for which is:

$$\text{Horsepower} = 602{,}432\ W\ R\ N \div 33{,}000$$

In this formula,

W = net weight on scales,

R = length of brake arm in feet,

N = r.p.m. of engine.

If the brake arm be made of such a length that $602{,}432\ R = 33$, it is evident that the above formula may be simplified to read:

$$\text{Horsepower} = P\ R \div 1000$$

The value of R in such case will need to be 5 ft. 3 in.

TYPES OF BRAKES

FIGURE 1 illustrates one of the simplest types of brakes consisting of a heavy wooden arm fitted with a belt to which a number of wooden blocks are fastened. This band is securely fastened to the arm at one end, having at the other a long adjusting screw and nut to obtain the correct pressure on the pulley. In using this brake, or in fact, any brake, the tension must be so adjusted that the engine will pull its full load without

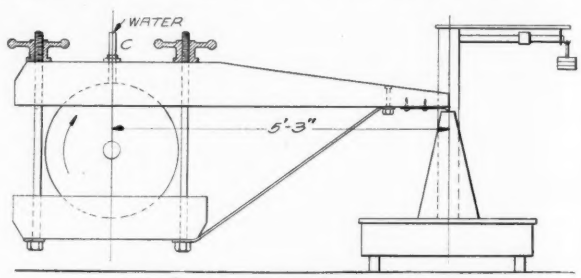


FIG. 2. WATER COOLED BRAKE

any diminution in speed, and unless the brake is provided with some sort of cooling arrangement to avoid causing it to grip the pulley, constant adjustment will be necessary. For cooling purposes, oil or soap may be used on small brakes and water on large ones.

The brake just described should not be used on engines of more than 5 or 6 hp.

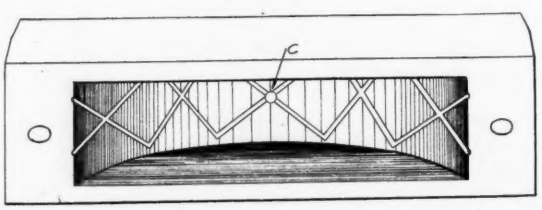


FIG. 3. VIEW OF PULLEY SIDE OF ONE OF THE SHOES—WATER COOLED BRAKE

An excellent type of water-cooled brake for use on engines up to 30 hp. is shown in Figs. 2 and 3. Figure 2 shows the assembled brake and Fig. 3 the pulley side of one of the brake shoes. Each shoe covers about ⅓ of the pulley circumference and has grooves formed in the concave surface so as to distribute the water, which is admitted at a pressure of about 30 lb. at point c.

One of the best brakes is that known as the Alden, shown in Fig. 4, which is applicable to almost any size of engine.

This brake consists of a central disk of cast iron keyed to the crank shaft of the engine and flanked on either side by a copper disk set into the brake housing by means of an expansion ring. Water is admitted under pressure between the housing and the disks, causing them to press tightly against the central revolving member, thus creating the necessary friction. The housing is provided with an arm which lifts a weight and enables readings to be taken in the ordinary manner.

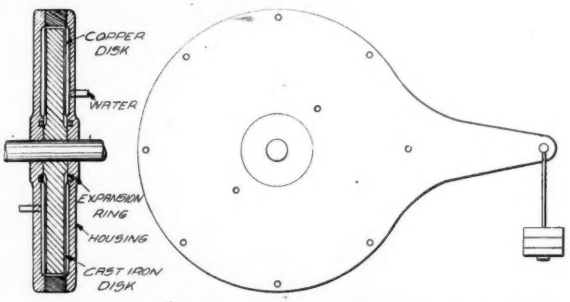


FIG. 4. SECTIONAL AND PLAN VIEWS OF ALDEN BRAKE

Obtaining the correct length of arm seems to be the most general source of error in making a brake test. The correct length of arm is the distance between 2 vertical lines, one passing through the center of the engine pulley and the other passing through the point where the brake arm rests on the scales, as shown in Fig. 1, or lifts the weight.

If the arm is in the position 1, R is the correct length; but if the brake be turned in position 2, R^1 is

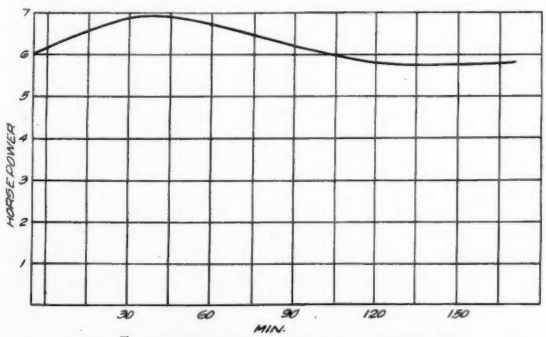


FIG. 5. POWER CURVE OF A GAS ENGINE

the proper length to use. The use of the distance, D, from the center of the wheel for the length of the arm in position 2 is in error by the amount, e, shown in the figure.

Results of Tests

If a brake test be made of any ordinary gas engine, it will be found during the first period of the test, say the first hour, that considerably more power will be developed than during the second hour. In other words, an engine that is able to develop 6 or 7 hp. during the first hour of a 2 or 3-hr. test will probably develop not more than 5½ hp. during the last half hour.

Figure 5 is a curve showing the drop in power of an ordinary gasoline engine after having run an hour or two. It is shown that the power developed gradually increased the first 30 or 45 min., after which it decreased until, at the end of 2 hr., it remained practically constant.

The reason for this peculiarity in gas engine performance is probably due partly to increased friction due to the heat of the engine, partly to a burning of the lubricating oil and partly to a dropping off of volumetric efficiency as the cylinder gets hot. This latter is undoubtedly the largest factor in causing a decrease in power.

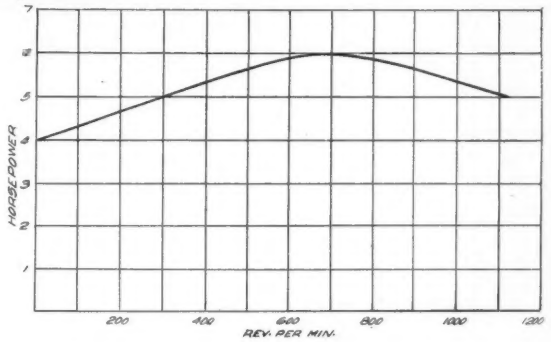


FIG. 6. POWER—SPEED CURVE—GAS ENGINE

Figure 6 is a curve showing the effect an increase of speed has on the power developed. Here it will be observed that up to a certain speed, a little beyond that for which the engine was designed, the power increases, but, after a certain speed is reached, the power curve drops rapidly. The reason for this generally lies in the size of the ports and the timing of the valves. The ports are designed to admit a certain volume of mixture in a certain time, and if, due to increase of speed, this time is much reduced, a full charge cannot enter and as a result the power will decrease.

The Perfect Day

WHEN you've started the day with a bunch of pep
And a zest for the old ham and—;
When you've swung to work with a springy step
As the tasks of the day you planned;
When you've pitched right in and raised merry hob
With the work that you found to do,
With a brain so clear that the meanest job
Was easy as pie for you—
Then the feeling you have as you hit the hay
Is a feeling of great content,
And *that* is the end of a perfect day,
Of a day that has been well spent. —Baers' Facts.

Preliminary estimates by John D. Northrup of the United States Geological Survey, Department of the Interior, indicate that the quantity of crude petroleum produced and marketed in the oil fields of the United States in 1916 was 292,300,000 bbl. This quantity is greater by 4 per cent than the corresponding output in 1915, which reached the record-breaking total of 281,-104,104 bbl. Mr. Northrop estimates that 38 per cent of the 1916 total came from the Oklahoma-Kansas field, 30 per cent from California, and the remaining 32 per cent from the Appalachian, Lima-Indiana, Illinois, North Texas, North Louisiana, Gulf Coast, and Rocky Mountain fields.

Fuel Investigations of the Bureau of Mines

IN the latest annual report of the Bureau of Mines, just issued, Director Van H. Manning has the following to say on the fuel investigations of the bureau:

The purpose of the Bureau of Mines in its fuel investigations is to increase efficiency in the use of mineral fuels and to disseminate information leading to this result. Current practice in the use of fuels is frequently based upon misconceptions as to relative fuel values, the nature of coal and the combustion process, and the method of heat transmission.

During the past year, work has been completed that makes possible the varying of furnace design in a rational manner according to the chemical properties of the fuel to be used. Heretofore furnace design has been largely a matter of cut and try, resulting in many uneconomical misfits and in the production of objectionable smoke. The Government undertook to remedy this difficulty and make available quantitative values for the use of engineers in designing furnaces. The first part of this work has been completed and a report of the results is ready for publication.

The Bureau of Mines advises other Government bureaus in matters connected with their fuel problems, acting on request in the capacity of consulting engineer in such matters as form the special work of the fuels division in the purchase and use of fuels. During the past year service has been rendered in this manner to the War Department, Treasury Department, Agriculture Department, Indian Office, Land Office, District Pumping Station, Government Hospital for the Insane, and Freedmen's Hospital, Washington, D. C.

Combustion in the fuel bed of hand-fired furnaces burning coal at rates of 3 to 20 lb. per square foot per hour was studied, such low rates being used in house-heating apparatus. Tests were made with 3 kinds of fuel, Pittsburgh coal, anthracite and coke. This investigation is now completed and a report is in course of preparation.

Experiments have been continued in a special furnace, having a long combustion chamber to determine the proper combustion space for burning nearly completely any given coal without producing objectionable smoke. A hand-fired grate was used and a similar series of tests are being run as with the previously used stoker. These experiments are giving quantitative results of value.

Heat-transmission investigations to determine the exact relation between the several factors governing the laws by which heat is transmitted from burning fuel to the water in a boiler will enable engineers to design boilers that will be more efficient as heat absorbers. During the year 1916 the factors particularly studied were the influence of initial temperature of the furnace gases and their velocity through the boiler tubes. Supplementary work done on commercial boilers consisted of a series of measurements of the temperature of gases as they passed through boilers of the following designs: Standard Babcock & Wilcox horizontal water-tube boiler; standard Stirling boiler; standard Heine boiler, and double-pass Heine boiler.

Investigations of both peat and lignite which have been carried on by the Bureau of Mines have already shown that large areas of peat of considerable value lie near great iron mines in northern Minnesota, which are now being worked entirely by coal brought a thousand miles or more from Ohio, Illinois and Pennsylvania. Many of the peat deposits of the United States contain an unusually high percentage of nitrogen and the peat has good fuel value as well and can be utilized by processes that are known to be thoroughly practicable on a large commercial scale.

The Bureau of Mines has since its inception had charge of the analyzing and testing of fuels purchased by the Government.

In order to attain the most efficient results an extensive investigation is needed of the fuels and the fuel-burning equipment at Government plants throughout the United States. At many plants there is waste from improper selection of fuel, use of inefficient or poorly designed equipment, and improper firing methods. There is lack of expert instruction of firemen, and a lack of information by plant managers as to what results other plants are attaining, and as to the standards for measuring actual performance.

The bureau has been able to attack the fuel problems of the Government in only a small way, because of its restricted authority and the limited funds available. It has, however, conducted investigations at some of the Government plants, on request of the department concerned. The advantages resulting are shown by the several specific instances of saving effected at several plants in the District of Columbia, aggregating about $50,000.

AN OPPORTUNITY is open in Australia to arrange for an agency for valves and fittings and similar hardware. Quotations are to be made f. o. b. New York or San Francisco, and cash will be paid against documents in New York or sight draft on London. Full details may be had from the Bureau of Foreign and Domestic Commerce, Washington, D. C., the number of the item being 23,431.

U. S. CIVIL SERVICE COMMISSION announces an examination for sanitary engineer, on Feb. 7, to fill vacancies in this position in the Philippine Health Service, Philippine Islands, at $1600 a year, and vacancies as they may occur in positions requiring similar qualifications, duties to involve engineering problems with regard to water supplies, sewage disposal, rat-proofing construction and drainage, and the preparation of plans and specifications for such projects. The following subjects will have the relative weights indicated: Mathematics, 30; sanitary engineering, 40; education and experience, 30. Applicants must show that they have graduated in sanitary engineering from a college or university of recognized standing, or that they have had at least 4 yr. experience in sanitary engineering work, and must have reached their twenty-first but not their fortieth birthday on the date of the examination. Applicants must submit to the examiner on the day of the examination their photographs, taken within 2 yr. Apply for Form B. I. A. 2. stating the title of the examination desired, to the U. S. Civil Service Commission, Washington, D. C.

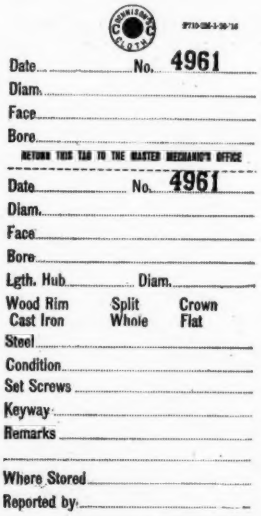
LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Pulley Records

As no doubt many of the readers of Practical Engineer, in addition to being in charge of steam plants, are master mechanics and superintendents of mechanical departments, and as such have supervision over general machinery repairs in factories of various kinds, the following may be of interest.

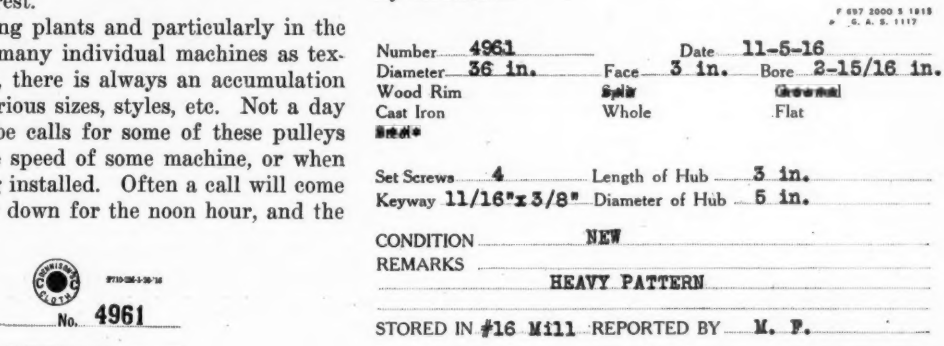
In all manufacturing plants and particularly in the larger ones that have many individual machines as textile mills, for instance, there is always an accumulation of spare pulleys of various sizes, styles, etc. Not a day passes but there will be calls for some of these pulleys in order to change the speed of some machine, or when a new machine is being installed. Often a call will come in just before shutting down for the noon hour, and the



THE SHORT STUB IS ATTACHED TO THE PULLEY; THE LONGER PORTION IS GIVEN TO FOREMAN IN CHARGE OF PULLEY INSTALLATION

change must be made before starting time. When no record is kept of the spare pulleys on hand, it is a hit and miss proposition to find the pulley wanted in the quickest time, especially if there are several places of storage, and much time and often production are thus lost.

The plan as here outlined and illustrated is used in a large textile plant where several thousand pulleys are in storage. Figure 1 illustrates a linen tag upon which is written the data of each particular pulley. The short stub is fastened to the pulley with wire, the number of the pulley is painted on the face in white, and the larger portion of the tag is detached and returned to the foreman of the department which does the work of changing and installing pulleys. Figure 2 represents a catalog card upon which the same data is typewritten and which is filed in the office of the mechanical superintendent. In each case the tag and card are filed according to pulley diameters.


Number 4961 Date 11-5-16
Diameter 36 in. Face 3 in. Bore 2-15/16 in.
Wood Rim Split Crown
Cast Iron Whole Flat
Steel
Set Screws 4 Length of Hub 3 in.
Keyway 11/16"x3/8" Diameter of Hub 5 in.
CONDITION NEW
REMARKS HEAVY PATTERN
STORED IN #16 Mill REPORTED BY M. F.

CARD BEARING SAME DATA AS LOWER PORTION OF TAG IS FILED IN OFFICE OF MECHANICAL SUPERINTENDENT

Thus one can easily and quickly ascertain if a pulley to meet a certain demand is in stock, and at the same time can have all the data concerning it together with its location. As a rule, where this system is in use, the pulleys in storage are under the care of one man, and by the use of the system he becomes familiar with the stock, all of which facilitates the finding of the material wanted. When a pulley is taken from storage and put into use, the tag, stub, and card are removed from the files and destroyed. C. A. J.

Precautions in Sampling and Analysis of Flue Gas

In all phases of engineering practice there are right and wrong methods for conducting work whether it be firing boilers, starting engines, or running tests. Nowhere is correct practice of more importance than in the sampling and analysis of flue gas by the Orsat apparatus where the results obtained are indicative of the general condition and operation of the boiler and furnace.

In several years practice the writer has found that a few simple precautions are necessary for best results. First, be sure that the solutions used in the pipettes of the Orsat apparatus are correct and not too old. These should be kept in glass bottles with rubber stoppers. On one occasion, I had sent to a chemical laboratory for a fresh supply of KOH solution for the determination of CO_2. When my next sample of gas

was analyzed no CO_2 was obtained. Repeated tests gave the same result. Upon inquiry we found that the assistant in the laboratory had misread the formula and not given us the correct solution. We now keep the formula for each solution pasted on the bottle in large type and when possible I prepare the solution myself.

The second precaution is this: Avoid long connections between the sampling bottle and the flue from where the sample is taken. Frequently in order to obtain samples from different passes within a boiler setting it is convenient to have small pipes leading to a point near the floor. It is far better to inconvenience oneself, use a short pipe connection and thus take the sample as near to the boiler pass as possible. One is more likely to obtain a fair sample in this way. Repeated determinations in these 2 ways have shown differences of 2 per cent in the percentage of CO_2.

Third, take samples by using sampling bottles. It is often convenient to arrange a place for the Orsat apparatus near the flue and take the sample of gas directly into the burette by first forcing out the air and then lowering the water bottle to draw in the gas. This method is convenient and rapid and has the advantage of few connections from flue to apparatus. However, the temperature of gas is likely to be higher and it is sometimes extremely difficult to draw in the sample because of the draft in the boiler pulling against it. I have found the sampling bottle more satisfactory chiefly because a larger sample is drawn out which is not only better mixed but allows an opportunity for results to be checked.

Fourth, be sure that all connections, rubber hose, corks, and nippers are absolutely air tight to prevent dilution of the gas with air, which would give incorrect results of analysis.

Fifth, in the operation of the apparatus be careful not to pull the solutions up into the glass manifold and over into the burette. Keep the same water in the water bottle and in the sampling bottles even though it becomes yellow and dirty. A layer of oil on the surface of the water is advisable. Whenever the apparatus is put away for a time, grease carefully with vaseline the glass cocks in the manifold. This will prevent sticking. If these precautions are taken, one may be reasonably sure of obtaining consistent and satisfactory results.

R. S. Hawley.

Putting Oil in Boilers

Putting oil in boilers for the purpose of removing scale does more harm than good when put on top of the water, for the reason that the sheets and tubes are wet and oil will not penetrate the scale but will form a coating over it, holding all dampness in the scale under it, which will work back through the scale and get to the tubes and sheets, causing corrosion and rusting of tubes and sheets.

I think the best way to use oil is the following: After the boiler is taken off line let it cool, but while boiler and setting have enough heat, wash the boiler clean and let the heat of the setting dry it out thoroughly, taking out all manhole and handhole plates. If necessary put a buzz fan at the bottom of the man head to circulate the air. When the boiler is perfectly dry, replace manhole and handhole plates, putting in the amount of oil you are to use. Devise some plan to fill the boiler slowly from the bottom. (In most tubular boilers the blowoff pipe is the lowest connection, therefore use it.) That will cause the oil to float on top of the water. The surface being dry, the oil will immediately take hold of it and soak to every spot in it. If it takes the boiler a week to get full of water, so much the better. Almost any plant has enough ¼-in. pipe, or even a small hose will do to connect to the boiler temporarily so as to fill as slowly as possible.

When the boiler is full, let it out slowly and perhaps a little oil will stick to the surfaces again. After the boiler is empty, open all manhole and handhole plates and let the boiler get thoroughly dry. When dry, set a pan of lime or charcoal inside and close up the boiler again. When ready for the boiler, remove the pan of lime or charcoal, pack all joints, putting in 10 or 15 lb. of soda ash or lye, boil out thoroughly, then wash out, fire up and cut it when necessary. If you don't you are sure to have trouble with priming.

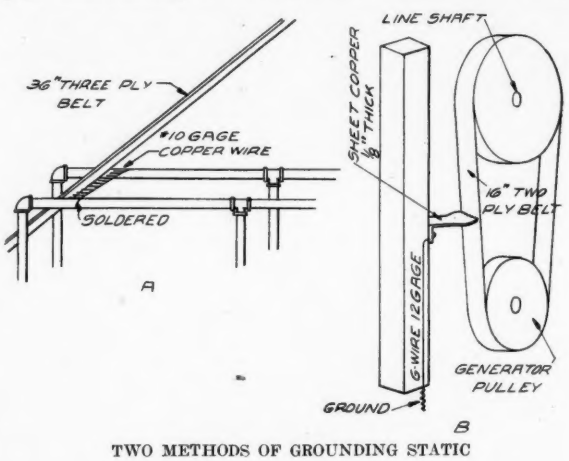
I would suggest, if the oil is of the heavy asphaltum base, to cut it with 3 or 4 gal. of refined coal oil, as that will make it more penetrating. A few years ago an engineer friend of mine was using oil the other way, and every little while he was having flue trouble, so I asked him to send me over one of the tubes he had just taken out. The tube was covered in spots with oil, that is, the scale was, and I chipped off several pieces of scale and it was wet and the tube was badly rusted and corroded. This boiler had been dry for 90 days. The idea came to me that the way he was using the oil had defeated the very purpose for which he was using it, and I suggested the above way of doing it. He tells me he is having better success than formerly.

Fred V. Broadaway.

Grounding Static

This happened in one of the large sugar factories in Colorado several years ago:

I was sitting behind the switchboard smoking my pipe and reading a trade journal. Presently I heard



TWO METHODS OF GROUNDING STATIC

a yell, but one must get used to all kinds of noises during the "Campaign" in a sugar factory. Pretty soon over came "Fat," the main engine driver, suffering with a severe scalp wound, and blood running in a stream.

"What is the matter, 'Fat'? I asked.

"Gee! That static on the big belt is something awful. You know there is only about 3 ft. between the belt and the valve gear (Corliss). Well, I went to stoop over to put a little oil in the dashpots when she got me. Naturally, I jumped and the end of the reach rod made this little cut in my head."

I secured some No. 10 gage copper wire and made a number of points on it about 2 in. long; this was soldered to the iron pipe guard rails, the points being about 2 in. from the bottom of the belt. This effectively grounded the static. See sketch A.

Not long afterward my helper told me that the moths were eating the insulation up on one of the generators, belt driven from the main line shaft. I suspected more static, and investigation proved that my surmise was right.

A partial re-insulation of this generator was necessary, but by using the method shown in illustration at B, a recurrence of this nature was prevented.

This is an old method, but I have known of several instances where it has been used to good advantage.

JACK L. BALL.

Where Safety is Needed

IN A New England power plant otherwise admirably managed, the most popular means of entrance and exit is via the rather hazardous route shown in the accompanying halftone. The station staff is thoroughly familiar with the inclined plank, which takes the place of a flight of steps never provided between the ground

A PARTICULARLY DANGEROUS ENTRANCE

and the engine room, but it would be hard to find a better case for "Safety First" than this. The combination of a steep and sometimes slippery plank resting on an unsecured wooden block, with a mass of empty oil barrels below, offers a peculiarly favorable foundation for an accident, and in presenting the picture it is hoped that similar makeshifts in other installations will be eliminated.

H. S. KNOWLTON.

Writing for Publication

THERE IS a neglected phase of opportunity that comes through writing for the technical journal—the failure of the writer to advance to the best personal advantage the publication of his work. With but slight effort, the proper promotion of an article will bring many individual and distinctive benefits, beyond any pecuniary profits, and the unusual possibilities afforded in this direction should not be overlooked.

Preparation of a technical article not only increases the writer's intimacy with the subject matter through the necessity for care and thought in presentation, but it quickens his perception along general lines, bringing apt and clear thinking with creation of new ideas and impressions as the work is perfected. The satisfaction of seeing an article in print should not be entirely self-centered, but should be extended to effect a more substantial and influential purpose. A splendid opportunity is presented to the writer to enhance greatly the value of publication to himself by "spreading the news," as it might be termed, in a direct and systematic way through channels that will bring increased personal standing. He should let his friends and others know that an article has appeared, thus multiplying the force of its publication to all possible advantage.

Presume, for example, that an article is published on an effective oiling system, turbine or engine installation, or covering other features of power plant work. A brief letter or post card should be mailed out by the writer to a selected list of desired recipients, informing them of the appearance of the article, the name and issue of the journal in which published, with a word regarding possible enjoyment and profit in reading.

This is making the most of the opportunity offered in a way to bring far-reaching advantages. It is going to the root of things and not neglecting the possibilities afforded to make one's knowledge and ability known to those who may be in position to spread the news still further in influential quarters. Repetition will drive home a thought or message with increasing power, and to be able to write and circulate personal letters of this nature at frequent intervals, covering either articles or brief discussions appearing in the technical journal, will cause growing appreciation for the capabilities of the writer and lead to beneficial and profitable ends.

L. R. W. ALLISON.

Boiler Inspection

IN R. M. PACKINGHAM'S article on boiler inspection he says in conclusion: " . . . this is not intended as a knock nor a criticism, but a plain statement of facts."

Now, to get down to a few facts. Where I went to school I was taught that if I knew of any defects in boilers or machinery, I should call the inspector's attention to them. Mr. Packingham states that he did not tell the inspector at the time about the split blowoff pipe in the third boiler. We all make mistakes at times, and the man that never made one never made anything else, so why not give him the benefit of the doubt? Perhaps he was troubled with a little indigestion at the time, or perhaps he had only ½ hr. to catch a train, and did not take as much time with the third boiler as he should have taken; or perhaps there was a lot of hot cinders in the combustion chamber that was burning the bottom of his shoes off. The next time the inspector came they were putting new tubes in another boiler, but the tubes were not beaded up, and the inspector reported all O. K. I do not suppose the inspector thought he himself would put fire under the boiler before he had put a pressure

on the boiler to see that they were taut, or the boilermakers would ask him to fill boilers before they had tubes beaded up in the first place. When the inspector saw all new tubes going in, he took it for granted that they would be taut, and as he saw no other defects, reported boiler O. K.

Then he goes on to say that there are pipes in the plant now carrying 125 lb. pressure that he knows could be punctured with a knife blade; in fact, one pipe was pierced with a hardwood toothpick 2 mo. ago. I think he had better grab a few wrenches, a hammer and chisel, go around where those good pipes are and see how much he can knock down in ½ day, then put up some decent pipes and joints.

As to his gages being out, all the inspectors I have met so far carry a test gage, and a small instrument to pull the hands off the gage, and none have refused so far to put on test gages if I asked them to correct the gages. Maybe where he is located there was no place to put on test gage; in that case he ought to put one on and have it handy the next time the inspector calls. In the part of the country where I am located you must have a place for the inspector to attach his gage; if he has any doubts about the gages, he will put it on whether you want him to or not. G. W. B.

In the Dec. 1 issue, on page 1004, R. M. Packingham has a complaint against his boiler inspector. I admit that a crack 15 in. long should be detected, especially if the pipe opened up; but if the crack was not opened, it is sometimes a very hard matter to detect such a crack. The inspector's report that all seams and tubes are taut is no reflection on the inspector. It is not necessary that the tubes be beaded in order to make them tight; beading is only to prevent the ends of the tubes from being burned by the hot gases and not to make the tubes stronger. If the tube ends could be protected from the hot gases, there would be no need of beading them; but when tubes are not beaded and the hot gases continually pass over them they burn off and crystallize, with the result the ends are weakened and may pull out. As to the steam gages being out 25 lb., it seems careless to operate a plant with steam gages out that much. Further in his comments he says that he has pipes in his plant carrying 125 lb. pressure and that they can be pierced with a knife blade. He seems to take pride in the fact that he operates his plant with the pipes in such dangerous condition. It is not the duty of the boiler inspector to inspect the piping of the plant; this work comes entirely under the engineer in charge and it is his fault if the piping is in such condition. A. C. Ruhl.

After reading the article by R. M. Packingham, in Dec. 1 issue, I am tempted to criticize it, partly in defense of the inspector.

He writes that his article is not intended as a knock, or as a criticism, but a plain statement of facts. It seems hard to believe that one of the oldest and largest insurance companies would retain an inspector in their employ who continually made false reports. The work of inspecting a boiler, to say nothing of a battery of boilers, is very arduous, and even the best inspectors sometimes overlook some details. It has always been my policy as an engineer to assist the inspector in his work of ascertaining the safe condition of the boilers, for my own life is dear to me; and should I see a weak spot in my plant, I should bring it to the attention of the inspector. He does not know your plant as well as you do, and the help you give him will make him a better and more thorough inspector. A great many complaints against him are exaggerated; but should I meet an inspector whom I knew to be careless and negligent in his work, I would consider it my duty to make a report of his case direct to the insurance company, or through the owners of the plant. The company will not keep in their service a man who will pass dangerous boilers.

Mr. Packingham states that he knows there are pipes in his plant carrying 125 lb. pressure that are thin enough to be punctured with a knife. If he believes in "Safety First," why does he not take steps to prevent an accident? Have those thin pipes anything to do with the boiler inspector? No, but they do vitally concern the engineer. Let us help the inspector if he is worthy of help; if not, then by all means take steps to secure his discharge from these important duties. C. H. Willey.

Diagram Criticism

I was much interested in the answer given J. B., on page 1007 of the Dec. 1 issue, regarding his indicator cards. As additional advice toward a solution of this trouble, I offer the following remarks:

Practically all wheel, or shaft, governors turn the eccentric ahead as the load decreases, and back as the load increases. As this eccentric is already too far back, a further increase of load will tend to augment rather than correct its position. This further corroborates the theory of A. L. R. that the knock is caused by late admission, as J. B. states that the knock increases with the load.

As a means of correction, I would advise removing a little of the steam lap. This will give an earlier admission and a later cutoff. The governor, however, will readjust the cutoff, and in its new position will give a little more compression, which will not be detrimental, while the release will not be materially changed. This is true for a governor which controls speed by both shifting the eccentric and varying the valve travel, which is the case with most wheel, or shaft, governors.

J. M. Row.

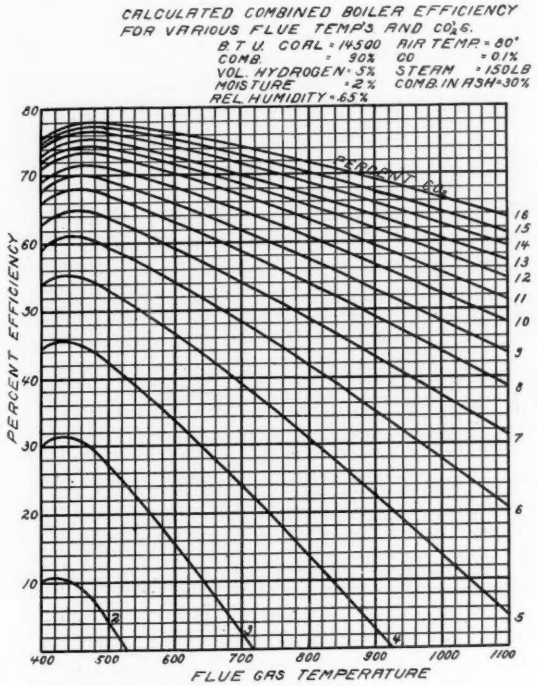
Loss Due to Soot

On page 827 of the Oct. 1, 1916, issue, under the heading "Soot Blowers," are some figures which appear somewhat misleading. These are shown in Table II, "Loss in Heat Conductivity of Boiler Plate Due to Soot Deposits."

Thickness of Soot	Per Cent Loss
Clean pipe	0.0
1/32 in.	9.5
1/16 in.	26.2
1/8 in.	45.2
3/16 in.	69.0

If the preceding figures are correct, the loss in heat conductivity would be directly proportional to the thickness of soot, or about 11.5 per cent per 1/32 in. of soot.

Unquestionably soot on boiler heating surfaces results in considerable heat loss and in the majority of boiler plants, good mechanical soot-blowers operated once or twice each day would be good investments; but expectations built on inferences from the preceding figures are most apt to lead to disappointment in results. In the first place, soot is not deposited evenly on the heating surfaces and even where the average thickness of soot is over 1/16 in., no reliable manufacturer of soot blowers would guarantee a saving or an increase in efficiency of as much as 26.2 per cent as a result solely of his soot blower.


CALCULATED COMBINED BOILER EFFICIENCY
FOR VARIOUS FLUE TEMP'S AND CO2'S.
B.T.U. COAL = 14500 AIR TEMP. = 80°
COMB. = 90% CO = 0.1%
VOL. HYDROGEN = 5% STEAM = 150LB
MOISTURE = 2% COMB. IN ASH = 30%
REL. HUMIDITY = 65%
PERCENT CO2
PERCENT EFFICIENCY
FLUE GAS TEMPERATURE

RELATION OF BOILER EFFICIENCY, PER CENT CO_2 AND FLUE GAS TEMPERATURE

A study of the accompanying chart may reveal the fallacy of the figures. This chart gives the net overall boiler and furnace efficiencies for various flue gas temperatures and CO_2. While it is given as only an approximation, its agreement with operating results is within about 2 per cent and it can be relied upon to illustrate the point.

Assuming furnace conditions practically constant, CO_2 equal to 10 per cent, boiler clean and flue temperature 500 deg. F., under these conditions the chart indicates a boiler efficiency of 71 per cent. According to Table II, as shown before, the loss due to soot deposit is 0.0 per cent. By applying the efficiency figures and chart, we get the following as a result of Table II:

THICKNESS OF SOOT	PER CENT LOSS ON ACCOUNT OF SOOT	PER CENT EFFICIENCY	FLUE GAS TEMPERATURE
Clean pipe	0.0	71.0	500°
1/32 in.	9.5	64.2	710°
1/16 in.	26.2	52.5	1000°
1/8 in.	45.2	38.9	1300°
3/16 in.	69.2	21.9	1680°

That is, with soot at 1/32 in. thick, the efficiency would be

$$\left[\frac{100 - 9.5}{100}\right] \times 71.0 = 64.2, \text{ etc.}$$

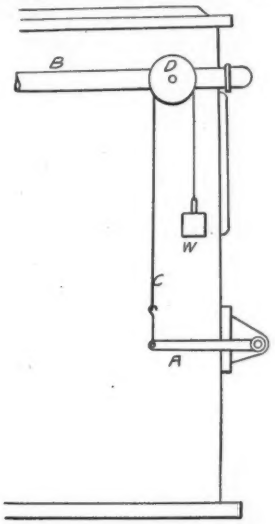
It is evident that high losses due to soot alone would be accompanied by extremely high flue temperatures, which ordinarily do not exist. When the flue temperature of 700 or 800 deg. or higher exists, some remedy additional to soot blowers is necessary.

The question is, under average conditions, about what is the average thickness of soot? More light should be thrown on the absolute heat insulating qualities of soot and tube slag, especially in the path of moving hot gases where the surfaces are constantly scrubbed by these gases. HAYLETT O'NEILL.

Homemade Float Valve

THE ACCOMPANYING sketch shows a float valve made by the writer for an open feed-water heater, which does the business at from 40 to 65 lb. pressure.

Wheel D, is about 5 in. in diam. and is fastened to the stem of a globe valve, a cord or chain, C, being passed over the wheel with a weight, W, on the end, and the other end being connected to the float lever, A.



WATER REGULATING VALVE FOR FEED-WATER HEATER

I had trouble with the ordinary float valve leaking with this pressure, also the valve would cut in a short time. I used a Jenkins globe valve, and when it leaks it is an easy matter to renew the seat. R. L. MOSSMAN

Babbiting Crosshead and Crankpin Boxes

SEEING AN ARTICLE in the Nov. 1 issue on babbiting crosshead and crankpin boxes moves me to give my my experience, in which I have always had success.

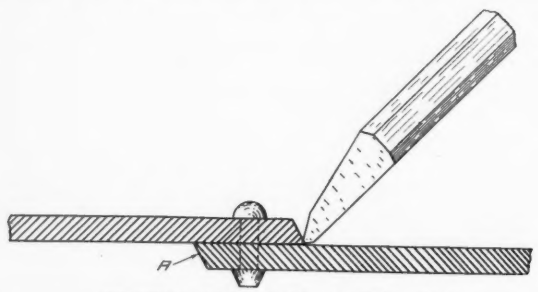
I am now running a crankpin box that I babbited 8 months ago and it has never given me a bit of trouble. I completed the job from start to finish in 4 hr. I do my babbiting on the crankpin. I bore a ¼-in. hole through center of brasses, through which to pour the metal, also put 1/16-in. hole in each corner for air to

escape and make the bearing more rigid. This does not materially weaken brasses. I put a thin coat of white lead on the pin and if necessary I use a stiff dough to keep the metal from running out of boxes. I never heat my babbit until I get ready to pour it, then I have it so it will scorch a pine stick. Dipping a tallow candle up and down 2 or 3 times before pouring makes the bearing smooth and but little scraping is required.

W. B. CRAWFORD.

Calking Gasoline Tank

NOTING W. E. C.'s request for information about calking a gasoline tank, I am sending a sketch of the method I have used to calk a tank of 3/8-in. steel. Scarf the edges, as at A, and calk with a chisel held at an



SHOWING METHOD OF CALKING SEAM

angle about as shown. Use an air hammer if possible; at any rate, use heavy blows, the main point being to fuller the inside edge of the scarf without cutting the sheet against which you calk.

C. H. WILLEY.

Value of Manufacturers' Instructions

WHAT IS the object on the part of the manufacturer of any appliance or apparatus in issuing directions for its use, and why are these directions so frequently given little attention by those who are responsible for the execution of the work which the appliance or apparatus is to accomplish?

In the opinion of the writer, the manufacturer's object is two-fold: To protect both himself and the customer. He hopes to obtain the good will of the customer through the good service of his goods and thereby obtain future business; he therefore makes every effort possible that the customer or the customer's employes may secure the best service from his goods, whether it be supplies or machinery. The manufacturer knows best his object as to service intended for his goods, and therefore is capable of making suggestions for its application; and should his goods prove a failure anywhere under any conditions of service, none are so vitally interested as to why it failed as he, none more ready to lend a helping hand in making a rectification. If it happens to be a misapplication, he will be the one most likely to perceive it, for the maker knows his goods best, therefore is most likely to give its use the most careful consideration from every angle. Any misapplication being noted and tabulated, he will advise in his directions methods of application to avoid such occurrences. Should it find its way into a field of duty for which it was not intended, he will be found ready to improve it for such service, or should this improvement seem inadvisable for any good reasons he will readily advise against its use for certain purposes (hence the manufacturer's directions).

Frequently while we may have used an article for a long period of time, without paying any attention to the directions, and perhaps thought we were getting good results, yet should we pause sufficiently long to observe the suggestions contained in the manufacturers' directions, we might possibly find one small item which would lead us to even better results if given proper consideration and applied as suggested.

As an illustration, a few months ago the writer noted the misapplication of one of the best steam and ammonia rod packings on the market, by a workman who the writer knew had been using it for a long period of time and received directions for its correct application with every box he ever used, yet failed to read the directions; negligent of the fact that he was not securing the service which the packing was capable of rendering, thereby costing the company employing him considerably more for packing than necessary.

The manufacturer of the goods would readily advise against any condition which will shorten the life of his goods, as he appreciates the fact that the longer the life of his goods in any plant the better the feeling will be towards his goods and the more satisfied his customer.

The writer, although disinterested except from a practical consideration of its use, could not refrain from suggesting a following of the directions.

On entering a plant several years ago the writer found a quantity of this same packing cast aside condemned, and was told by the superintendent that it wouldn't hold anything. The writer applied it to a rod with excellent results, which caused its use in that plant again for a long period of time.

It has been my observation that men responsible for the purchase and application of different articles will receive detailed directions as to their use, which are in turn either thrown in the waste paper basket or stuck back in a desk drawer never to be seen again.

The article is then handed over to a workman with a few minor remarks as to its application. Perhaps he gleans enough from these remarks to understand thoroughly its application for best service, and perhaps he does not.

Why not hand these instructions over to the workman, go over them carefully with him and instruct him to follow them closely? After being well tried out according to directions, if it is seen that in your particular case the directions can be improved upon and thereby better service can be secured, try for the better service.

JOHN CORLISS KAHL.

U. S. CIVIL SERVICE COMMISSION announces an examination for laboratory assistant, on Feb. 7 and 8, to fill vacancies in the Bureau of Standards, Department of Commerce, at entrance salaries ranging from $900 to $1200. The applicant must show that he has graduated from a 4-yr. course at a college of recognized standing, or that he is a senior student in such an institution and expects to graduate within 6 mo. from the date of the examination, and must have reached his twentieth but not his thirty-fifth birthday on the date of the examination. Apply for Form 1312.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Engineers' Qualification in Massachusetts

I HAVE HEARD considerable comment as to the necessary qualifications (both practical and theoretical) of an engineer of the third class in the state of Massachusetts, but wish some of the readers of Practical Engineer would kindly give me some definite information regarding this subject.

I would also appreciate having the following questions answered:

1. How and where would you measure to obtain the true thickness of the shell plates of a boiler having been in service for some time?

2. If you discovered a boiler blowoff pipe bearing on the sleeve where coming through the setting, what would you do?

3. If you advance the eccentric on a Corliss engine, is the speed of the valve increased or decreased? Why?

L. B.

Oil Separator on Exhaust Line

WHEN EXHAUST STEAM is used to heat feed water in an open heater, is it necessary to place an oil separator between the engine and the feed-water heater?

W. S. M.

A. It is always best to have an oil separator between the engine and an open feed heater, as otherwise the oil carried by the exhaust steam will go over to the heater and be pumped back to the boiler, where it will coat the heating surface, and is likely to produce overheating and bagging.

It is, also, well to have a settling chamber in the heater, which will allow the oil not taken out by the oil separator to rise to the surface and be drawn off, and usually the feed water is also filtered to assist in the removal of the oil. A. L. R.

Some Massachusetts Examinations Questions

WHY ARE the tubes of a B. & W. water-tube boiler inclined?

2. What is the purpose of an ogee ring on a Manning boiler?

3. Where do staybolts usually fail in this type of boiler?

4. How would you know that an engine with a shaft governor cannot run away without taking off the steam chest cover to examine the valve?

5. If the piston rod of an engine is a taper fit and is keyed into the crosshead, and the crankpin and crosshead boxes are of the gib and key type, what is the gib and key used for? Why is the gib made tapered?

A. A. H.

ANSWERS

THE TUBES of a B. & W. boiler are inclined in order to aid the circulation of the water.

2. In regard to the ogee ring on the Manning boiler, you will understand that the purpose of the Manning construction, in the first place, is to get a larger furnace and firebox. It is a somewhat more expensive construction than the straight fire-tube vertical, but has a larger grate in proportion to the main shell, and because of its construction with the ogee ring, it permits of come and go in the length of the fire tubes without putting strain on the shell, plates or joints. In the case of the straight shell vertical tubular, this strain exists but is taken care of as best may be by spring of the tube sheets and of the tubes.

3. The staybolts in a Manning or any other similar type of boiler, having a deep internally-fired furnace or waterleg, usually fail at the upper end of the furnace. The reason for this is, that the inside sheet is subjected to a higher temperature, especially if coated with scale, than the outside sheet, and the expansion is greater. In long waterlegs, the difference in expansion between the inside and outside sheet is great enough to cause a bending strain on the staybolts at the upper end. This repeated bending may, in time, cause them to break off more easily than those lower down.

4. We suppose that you are referring to the fact that with the governor arms out or in the full-speed position, the lead of the valve should be zero. To determine if this is or is not the case, without opening the valve chest, place the engine on dead center and open the throttle valve, having, at the same time, blocked the governor arms in their extreme or full speed position. If any steam passes through, the valve has lead, which it should not have. The governor must, when it is full speed position, practically blank the port. You will realize the truth of this statement when you stop to consider that, should the engine have any lead at all when the governor is in its full speed position, it will be impossible for the governor to cut off entirely the steam supply, in which case, the engine is bound to run away.

5. The gib used on a connecting rod is for the express purpose of holding the strap in place, and also to eliminate a direct shear on the key. The gib is made tapered in order that the motion which results when the tapered key is driven down may be applied perpendicularly in drawing in the strap and tightening up the brasses. The taper of the gib is equal to that of the key in order that the wedge action of the key shall be parallel to the vertical surfaces of the shim and brasses, thus providing perfectly uniform bearing surfaces between the tapered key, the shim and the brasses.

We presume the question as asked may have reference to the possibility of using more or less shims behind the inner half of the box, at either end of the connecting rod, in order to take care of wear and keep the length of the rod such as to divide the clearance equally between the two ends of the cylinder.

With a piston rod having taper fit in the crosshead, the length of the piston rod cannot be changed, hence the wear on the halves of the boxes next the end of the connecting rod must be compensated by putting in shims between the rod ends and the boxes, otherwise the rod will shorten with wear and the piston be drawn nearer to the crank end of the cylinder, reducing the clearance at that end and increasing clearance at the head end.

W. P.

Peculiar Governor Behavior

WHAT WILL CAUSE a governor to race when it gets down to a certain position, regardless of steam pressure or load? The belts or gears do not slip, and as far as the eye can discern, there is no tight bearing or connection in the governor. SUBSCRIBER.

A. We take it that the governor you refer to is of the type usually found on Corliss engines.

Several cases of a similar nature have come within the experience of the writer, and in each instance it was found that there was some place where the parts did not move freely enough.

If the unit is a new one, it may require some time to locate the seat of trouble. It may be only a bruise on some of the parts caused in shipping or rough handling. For instance, the writer once found that there was a slight bruise on the governor spindle in such a position that when the governor was coming up to speed, it required about 10 revolutions over the standard before the governor moved, and when it did, it immediately flew to the top limit of travel where it stayed till the speed reduced to normal, when the engine worked all right as long as the steam was high and the load light.

When the steam dropped or the load increased, the governor dropped enough so as to bring the bruised spot in contact with the bored bearing in which the governor revolved and which the fit was not over 0.001 in. large. Here the spindle stuck until either high or low speed caused it to move one way or another, and this racing continued as long as conditions were favorable for it. Of course, it required quite a hunt to discover the cause, for there were a number of places where such an occurrence could take place. When once found, a few strokes of a dead smooth file remedied the trouble, and the engine regulated properly after that.

As far as the writer has observed, all engine builders use either letters or figures to mark the assembled governor so that in case it becomes necessary to dismantle it (as is usual when shipping or when making repairs), the several parts can be re-assembled in the same relation as when first built.

Even the various parts are made as near uniform as possible with jigs and templates, yet there are certain little refinements in the process of assembling that make the several parts work with freedom when assembled just one way, and if placed in any other way, or 2 parts similar in every respect, as far as the eye can detect, be interchanged, that freedom of action is lacking, to the detriment of the governor as a whole. Even as simple a thing as a straight pin, if reversed when being placed in a hole, and on which 2 or more parts move ever so slightly, may cause the engineer not a little worry on account of the annoyance.

Again, the cause of the disturbance may not be in the governor mechanism itself, but in the gagpot, or dashpot, or whatever device is provided to prevent the governor from responding too promptly to changes in the load. The writer once traveled several hundred miles to put a quart of oil in the gagpot of a governor which was very erratic in its movements.

Near the top of the bore of the gagpot was a slight projection as if a round nose chisel had been dropped against it, and as there was no oil in the pot, as soon as the governor began to rise with any sudden falling off of the load, it would rise too far—that is, more than it should even for friction load—and the plunger of the gagpot would catch on this projection and hang there till the speed had reduced so low that gravity began to act, and then the governor dropped too far with the result that the speed would increase several revolutions above normal.

As it was night when I arrived on the job and the plant was a "one man situation," advantage was taken of his absence to fire up, to do a little investigating with the result as stated, and for the first time in several months the patrons of the plant had steady lights, much to the discomfiture of the engineer.

Next day investigation revealed the slight abrasion which was readily removed with a scraper, and the pot refilled with oil.

There are a number of places where additional friction may be incurred by rough usage, or handling and which will cause the trouble you have experienced, and one must study his engine and its peculiarities, for they all have their whims much the same as all engineers.

G. H. WALLACE.

Precautions in Placing Piston Rings

WHAT PRECAUTIONS would you take before and during the time you are putting new rings onto a piston?

READER?

A. Before putting in new piston rings, they should be tested in the cylinder to make sure they are of the proper diameter, and should also be tested in the grooves to make sure they are a free fit sidewise, but not too loose. This can be done by sticking the ring into the groove and rolling it around to be sure that there is no binding at any point of the ring.

To put a set of snap rings on a solid piston, it is necessary, of course, to take the piston out of the cylinder. Then the rings are opened up sufficiently to let them pass onto the piston, and are pushed along until they slip into the grooves.

If it be necessary to pass a ring by a groove, this may be bridged at a number of points with strips of thin sheet iron, so that the ring will slide over the groove beyond without dropping in. O. H. H.

A Power-Factor Correction Problem

WE HAVE a 100-kw., 220-v., alternating-current generator driving 57 3-phase induction motors ranging in size from ¾ to 7½ hp.

While the power factor will at times average 86 per cent, there are times it will drop to 65 per cent. Assuming that we are able to maintain it at about 86 to 88 per cent, would there be any economy in installing a condenser motor so as to raise the power factor to 96 per cent? R. K.

A. In a plant the size of yours it will hardly pay to put in a condenser motor to improve your power factor, since the reduction in current loss will not be sufficient to pay for the fixed charges on the motor. If you have occasion to add a good sized motor to your outfit, it might pay to put one in of the condenser type, as this will involve no great amount of extra cost.

The only loss that comes from the low power factor is the larger current required to give the necessary power. When your power factor is down to 65 per cent, it is probably because your motors are running at a light load, hence the amount of current taken is small, and as the motor load increases, so that the current becomes larger, the power factor is raised, giving better transmission efficiency.

If you are having trouble to get the necessary amount of power from your generator, it might then pay to put in a condenser motor, and improve the power factor simply as a means of increasing the power output of the generator. A. L. R.

Determining Bearing Power of Soils

WHAT METHOD should you use to test soil in order to get its bearing power?

2. How do you figure the number and size of bars entering into reinforced concrete construction?

3. What information have you for figuring the pressure and displacement required for a given quantity of water to be raised a certain head in air lift work?

4. What size generator would you recommend for a farm house light plant requiring about 25 40-watt lights? How do you figure it? S. D. J.

ANSWERS

THE BEARING pressures allowed on various soils have been experimentally determined, and standards have been adopted which differ but little in the various parts of the country. After digging a test pit to determine the quality and thickness of the soil, one can reasonably assume a bearing power.

The laws of Chicago specify 1¾ tons for pure clay, 15 ft. or more thick; 2 tons for pure dry sand, 15 ft. or more thick; and 1½ tons for a mixture of clay and sand for the same depth.

Ordinary practice gives the following: 200 tons per square foot for solid bed rock; 5 to 25 tons per square foot for rock broken but well compacted; 4 tons per square foot for pure clay, 15 ft. or more thick; 1 ton per square foot for soft wet clay; 8 tons per square foot for gravel well packed and confined; 4 tons per square foot for pure dry sand well packed and confined; 2 tons per square foot for pure dry sand in its natural bed; ½ ton per square foot for quicksands and marshy soils.

2. The amount of reinforcing steel used will depend upon the safe bending moment of the beam. A formula commonly employed for safe bending moment of a reinforced concrete beam is:

$$\text{B. M.} = \frac{W l^2}{10}$$

in which W = the total load on the beam, per square foot, and l = the length of the span.

In order to find the minimum thickness of the slab or beam, and the area of steel required per foot of width for a maximum resisting moment of a slab of given thickness, we shall consult 2 tables which are furnished in any reliable text on concrete reinforcement.

Example:

Find the size of reinforcing necessary in a concrete slab with 8-ft. span, and which is to support a live load of 75 lb. per sq. ft., assuming a maximum fibre stress in the steel of 18,000 lb., and maximum stress of 650 lb. per sq. in. for the concrete.

From the table of minimum thicknesses we find a thickness of 3.5 in. given for the 8-ft. span, and a load of 100 lb. per sq. ft. It is best, however, to make this thickness 4 in.

Then the dead load of the 4-in. slab will weigh 48 lb. per sq. ft., and plus a live load of 75 lb., we have a total load of 123 lb. per sq. ft.

From the formula, $\text{B. M.} = \frac{W l^2}{10} = \frac{123 \times 8^2}{10} =$ 787 lb., and corresponding to this load, we find in the table that a cross-sectional area of 0.18 sq.in. of steel reinforcing is recommended. Whether this reinforcing is best applied in more than one bar or in the form of a mesh depends largely upon the purpose of the work and the nature of the load.

3. Where the total lift and running submergence are known, the following formula may be used to calculate the approximate amount of free air required:

$$V = L \div [\log (S + 34) \div 34 \times C]$$

Where V = free air required to pass one gallon of water;

L = total lift in feet;

S = running submergence in feet;

C = constant.

Values of C with proper submergence:

Lift in ft. (L)	C
10 ft. to 60 ft.	.245
61 ft. to 200 ft.	.233
201 ft. to 500 ft.	.216
501 ft. to 650 ft.	.185
651 ft. to 750 ft.	.156

The necessary pressures can be calculated from the following: Starting pressure = (depth of pump or foot piece in well less the static head or starting submergence) × 0.434. Working pressure = above value + friction in pipe + 2 lb. back pressure in pump.

4. A generator supplying current for 25 40-watt lamps must be capable of developing 25 × 40 = 1000 watts, and thus a 1-kw. generator would be installed. W. P.

Relative Economy of Engines

WHICH IS the more economical in the consumption of dry saturated steam, a low-speed Corliss 4-valve engine equipped with drop valves or a high-speed slide-valve engine with automatic cutoff?

We intend to install a new engine, but do not know which to select. The manufacturers of the automatic cutoff engine claim a steam consumption of from 20 to 22 lb. per hp.-hr., while the Corliss engine would take from 24 to 30 lb. of steam per horsepower-hour. Q. D.

A. It is impossible to make a general statement as to the relative economy of the 4-valve Corliss engine and the high-speed slide valve, as so much depends on the design of the engine.

Theoretically, for the same piston speed, clearance and tightness of valves, there should be no difference between the two. The higher the piston speed, the better should be the steam economy, because of less initial condensation. The larger the clearance, the poorer will be the steam economy, and, of course, a leaking valve is always a source of loss.

The only way to be sure, in making your decision, is to request both engine builders to submit a bid with guarantee of steam economy under test, preferably after 6 months' running, and a cash penalty for failure to reach this guarantee, or a bonus for exceeding the guarantee. With this data in hand, you will be able to decide which maker is more likely to make good on his claims. A. L. R.

Corliss vs. Poppet Valves

A SUBSCRIBER asks for information as to which is the more efficient, the Corliss engine or poppet valve engine, assuming both to be in good condition with tight valves, and the reason thereof. Much might be said in favor of either side of the case, as both types represent the highest efficiency in their respective lines; but the most economical operating conditions of the two types are different, and therein lies the difference in their efficiency.

The simple Corliss engine running noncondensing has a steam consumption of about 22 lb. per hp.-hr. when using dry saturated steam at 125 to 140 lb. pressure. When running condensing with 25 to 26 in. of vacuum, which is the most economical for this engine, the steam consumption for a single-cylinder engines is about 20 lb. per hp.-hr. Compound condensing engines will show an efficiency of 15 to 17 lb., and slightly lower when operating on superheated steam or higher pressure. These rates are for cylinders with valves in good condition and carrying a full load. The Corliss engine has short ports and the clearance volume is considerably less than slide or piston-valve engines, which helps to account for its high economy, and the arrangement of the valves is such that the most economical steam distribution may be had. The design of the valve gear in the drop cutoff type, which is the most efficient of this type, prohibits a speed greater than about 150 rev. per min. and the cylinders must be correspondingly large with long stroke to obtain power. This causes a greater temperature drop in the cylinder, and more initial condensation than occurs in cylinders operating at higher number of revolutions, with shorter stroke and more uniform cylinder temperature. This loss is to some extent overcome by compounding and superheat; but when superheated steam is used, there is a tendency for the valves to warp from high temperature and leak, and lubrication of the valves is more difficult. In short, the most economical operating conditions for a Corliss engine is a medium pressure from about 125 to 150 lb. dry saturated or slightly superheated steam; speed about 600 ft. per min. and not over 125 r.p.m., with cutoff about 1/3 stroke. In the double eccentric Corliss, cutoff may be later with good efficiency, but not beyond ⅝ stroke.

The poppet-valve engine, as built now, shows a lower steam consumption, and the following figures are taken from various published reports of tests. A simple noncondensing Lentz engine running with steam at 155 lb. gage, and 245 deg. of superheat at 208 r.p.m. used 15.24 lb. of steam per hp.-hr. A Nordberg cross-compound uniflow engine running 200 r.p.m. with steam at 150 lb. gage and 100 deg. superheat, showed an efficiency of about 11 lb. per hp.-hr. A Skinner uniflow engine with poppet valves running noncondensing with dry saturated steam at 145 lb. pressure, showed an efficiency of 21 lb. per hp.-hr., and when running condensing with saturated steam, the rate was 17 to 18 lb. When running condensing with 100 deg. superheat, the steam consumption was 12 to 13 lb. per hp.-hr. or about 3 to 5 lb. under what could be expected from a Corliss engine.

A part of this saving, however, is due to the uniflow cylinder and not all to the poppet valves. It is claimed that in Germany the uniflow poppet valve engine has developed a horsepower on from 6 to 8 lb. of steam under the most favorable circumstances.

The advantages of the poppet valve engine are that it is designed to operate at high pressure, sometimes 200 lb., and high degree of superheat. The speed is also considerably higher than for a Corliss engine, conditions which are not favorable to Corliss engines. The valves have a very short lift, and are worked positively from cams; but the steam distribution is not so good as may be had in the Corliss cylinder, which partly offsets its advantages, and the apparently lower steam consumption is due to higher temperature, higher speed of revolution per minute giving less cylinder condensation and higher pressure, rather than to economical steam distribution.

It is claimed that the poppet valve, as the double-beat type, is not so efficient as the single beat, due to the difficulty of getting the seats tight and keeping them so, although the double-beat valve is balanced and works easier. It is also stated in the various reports that a greater overload can be carried with the poppet valve, and one report says that a 100 per cent overload will only decrease the efficiency about 10 per cent.

In the Corliss valve proper, sufficient steam valve lubrication is essential to good operation, as it presents a comparatively large wearing surface which, if not well lubricated, will cause the valve to hang, and cutoff will be bad, while in the poppet type the valve lifts off its seat and the stem only needs lubricating.

A number of advantages are to be found in each type, and the proper type to select for a given plant will depend not only on the engine itself, but upon the available steam pressure; whether or not superheated steam can be had, how much, and on the nature of the work which is required of the engine. J. C. HAWKINS.

Boiler Operation Questions

WHY DO the tubes of a boiler such as the Heine buckle upward?

2. What should be done when the mud-drum nipples of a B. & W. boiler start to leak? What would cause this?

3. What would you do if a B. & W. boiler sank on the foundation? How would you bring it back to place?

M. F. T.

ANSWERS

IF YOU ever turned steam into a large header or steam main, of comparatively short length, you may have noticed that it buckled in the center and for half a minute or so was supported only on the 2 end supports. This is because when the steam is first admitted slowly into a cold header it naturally rises to the top so that the top of the pipe warms first and consequently expands more than the bottom until steam enough has been admitted to heat the entire pipe to the same temperature.

This is practically what takes place in the tubes of a straight tube boiler which buckles upwards in the middle, only due to a difference in temperature of the water contained therein.

The cause of the difference in temperature is either the sudden entrance of cold air when the fire is charged, when cleaning or stoking tools are used, or when the boiler is cut out and allowed to cool too rapidly.

The tops of the tubes are generally covered with a coating of soot which acts as an insulator for the time being and when, due to dampers and draft doors being left open, the cold air strikes the bottom of the tube, it contracts more than the top, which does not get the direct effect of the blast; even the slight coating of soot is not present. This process repeated numberless times in the life of a tube, which is restrained between 2 practically rigid parallel manifolds, will cause the tube to be permanently buckled the same as is any piece of metal subject to intense heat on one side and cold on the other.

2. The only thing to do is to roll the tubes the same as you would the other tubes of a boiler. While you might have a roller for all ordinary purposes, yet you might not be able to get into the corners with it for the outside tubes. For these restricted places a roller with a jointed taper pin is used.

Unequal expansion and contraction causes these tubes to leak as well as chemical action, presence of impurities in the water, while the material in the tubes not infrequently has something to do with it.

3. Generally speaking, most boilers being installed within the past several years are suspended and it is hardly possible for them to settle unless the footing gives way under the supports, in which case it will be necessary to take the proper steps to renew the footing by supporting the boiler on blocking while new footing of the proper sustaining capacity is put in, under the supporting columns. But if the boiler is of the type which has supporting lugs on the shell or headers, which rest on the brick setting, then if the brick work fails through action of the fire on the walls, the only thing to do is to level the boiler to its original position and renew the setting, either wholly or in part, as conditions may demand. In case this is necessary, support the boiler on blocking after raising it to the original position with whatever means are at hand and renew the setting. Be sure that there is a plate of ample size on the wall for the boiler lug to rest on and that there are rollers or balls enough between to insure free expansion of the boiler.

It is entirely possible to take a boiler with wall lugs and support it from a cross beam resting on columns outside the setting, by a little careful calculation and study, the supporting columns may be made of common I beams of the proper size with footings riveted on top and bottom, or double channel irons will do, if well riveted together.

The cross pieces over the boiler should be made of channels spaced far enough apart to admit of the supporting rods passing up between them where a substantial washer and double nut permit the boiler to be brought to the required position and kept there.

This kind of a support on an old boiler does not present any great difficulties. All that it is necessary to do is to know the weight of the boiler when full of water, and calculate for this weight with a reasonable factor of safety.

A stirrup of iron of ample size, such as 1 by 4-in. mild steel, or stronger, slipped over the wall lug, makes a good device, as a supporting bolt with a substantial eye in it can be slipped between the 2 ends of the flat iron and a pin or heavy bolt put in. G. H. WALLACE.

Changing Engine Speed

I HAVE CHARGE of a 14 by 36-in. Corliss engine running at 82 r.p.m. which I wish to speed up to 100 r.p.m. Can I obtain such increased speed by the adjustment of governor rods alone, or shall I have to change the governor weights?

2. I also have a direct-current generator which, although just returned from the repair shops, absolutely will not run cool. In fact, it even melts the solder on the commutator segments. The machine is now shunt wound. Would it be possible to run it series wound with any better effect? H. E. C.

ANSWERS

IT WILL not be possible to increase the speed of your engine up to 100 r.p.m. simply by altering the adjustment of the governor rods. You will have to increase the weights on the governor, and it is probable that, for as large an increase of speed as this, you will have to change the governor pulley. This change should be made so that for a given speed of the engine the governor will run slower than before; that is, the pulley on the governor must be increased in diameter in the ratio of 100 to 82.

2. In regard to your dynamo, this must be seriously overloaded if it runs so hot as to melt the solder on the commutator segments. If this happens at different points all around the commutator, and the armature wires get hot all around, it is evidently a case of trying to carry too much current. If there are only 1 or 2 points where the solder melts, and the heating in the armature is in 1 or 2 spots, it would indicate a short-circuited coil, the short probably being in the commutator.

It will be impossible to run your shunt-wound dynamo series-wound, as the windings for series and shunt connections are entirely different. A. L. R.

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Specifying Modifications of Standard Equipment

Shall the operating engineer whose advice is asked relative to the purchase of new equipment hesitate to recommend departures from standard products if he feels that a real gain to the plant will result? The answer is obviously "No," and yet there is no question that some engineers blessed with good ideas need encouragement to commit themselves more freely along this line. Opportunities for putting original views into effect may be relatively few in connection with the purchase and installation of large apparatus units, but there is surely a field for excellent work in connection with all sorts of minor equipment and supplies where the operating man's ideas based on experience may be given at least an occasional tryout, even if they involve some departure from cut-and-dried practice.

In the choice of pumps or motors for auxiliary service, for instance, the available capacities and speeds may not come near enough to the local requirements to permit operation within the range of efficiencies desired. The manufacturer's salesman may recommend the nearest standard size, but a little figuring on the part of the engineer may show that the yearly cost of accepting the former's proposition may be several hundred dollars more than if a pump or motor of the particular size and speed wanted were installed. If an intermediate size or speed range best meets the case, after careful figuring of fixed and operating charges, the engineer who "sticks out" for that size or type and who stands ready to justify his viewpoint commands the respect of the progressive employer. He may be over-ruled, but at least he has given the best advice that is in him and can assure himself that if the advice is not taken it is no fault of his.

Far more important, however, than the specification of non-standard sizes of equipment, is the recommendation of radical departures in design from well-tried standards. Friendly discussion of the points involved with the various manufacturers' representatives is a good thing, both for the engineer and for these other workers in the engineering field; but unless the engineer becomes convinced that his views may properly be given up or put in "cold storage," it is a mark of professional weakness to fail to advance those views with all the ability at one's command. The manufacturer often has the benefit of a wider observation of the working of his product under varied conditions, but there can be no better judge of its fitness for particular service than the operating man who has handled the apparatus day in and day out under the stress of actual responsibility for hour-to-hour results. And if a plant engineer comes thus to the conclusion that certain departures in design are feasible and worth their cost, it is clearly his duty and his privilege to make the point plain to his superiors. If it is possible to base views of this sort upon experiments with home-made equipment or upon special tests upon modified standard apparatus, so much the better. In the long run, operating men learn many things about the behavior of standard equipment that are well worth passing on to the designer. Variation from normal products for the mere sake of individuality is an entirely different matter from vigorous recommendation of improvements which appear to be justified from service observations or skilled investigation.

Editorial Comments

In many industries where some of the product of the company is used in production no special efforts are made to economize in its use. Coal mining has been notorious in its waste of fuel for power purposes. This short-sighted policy, however, is giving way rapidly, particularly among large mining companies, to rigid economy in the use of coal. In many cases the mine power plant is compelled to use mine refuse which other coal consumers will not buy. Such a plant is described in the leading article of this issue, and the peculiar operating conditions as pointed out and the means employed to serve the mine will be of particular interest to all power plant men.

Many engineers, thoroughly familiar with and competent to operate the largest sizes of reciprocating engines, hesitate to undertake charge of steam turbines. Although they may know how turbines are constructed and the principles of operation, the troubles which may arise due to the high speed and the extreme delicacy of balance necessary for safe operation loom up big and take away ordinary self-confidence. Eustis H. Thompson has prepared articles for readers of Practical Engineer on the subject of correcting turbine balance which deal with a vital point in operation and treat the subject in a thoroughly practical manner. The first appears in this issue.

What would you do in case of fire? Now shut your eyes and imagine a blaze has started somewhere in your plant; you know it might start almost any place. Instantly surround yourself with conditions as they exist except that a destructive fire is at work. Could you, in the excitement that is sure to accompany such a condition, put your hand on the proper apparatus and extinguisher? Read how H. L. Gannett would fight an electrical fire. It is quite probable that you will be reminded that proper provision has not been made in your plant.

Can a fireman who is required to tend the furnace, watch the steam gage, the draft gage and the water gage, regulate the damper, regulate the feed water and occasionally take a peek at the smoke stack secure highest efficiency from the boiler? We doubt it. To relieve him of at least one duty, the automatic feed water regulator performs a service even better than can be done by hand. In this issue a series of articles on feed water control is begun which will be of aid to those desiring to equip their boilers with these devices as well as familiarizing others with the construction and operation of modern types of regulators.

The one principal chemical operation in the power plant is the combustion of coal and in this process is found the master key to economy. The subject must be mastered if success is to be attained. Each year brings forth new instruments to aid firemen, and eminent engineers are constantly experimenting and investigating in order to increase efficiency of combustion. In this issue Mr. Bement presents the first of a series of articles on the subject, which will be of value to the experienced and the inexperienced, for many conditions and relations are presented in a new light.

In the reliability of a fire-alarm system may lie the saving of a plant or factory, and those Mr. Hawkins describes have been tried out and found dependable. Any engineer can install one at comparatively low cost.

The tendency of nearly all in charge of the operation of power plant machinery is to neglect the study of those conditions which are not forced upon them by troubles. It would be well to give considerable thought to the points brought out by Mr. Hall in this issue on the design of direct-current machinery. If you have commutator trouble it may not be due to such a simple thing as the wrong type of brush; the machine design may not be proper for the conditions. Just read this article carefully.

Sometimes as much skill and planning are required to tear down as to build up and to fell a chimney without doing great damage to surrounding buildings, as described by Mr. Scholefeld, is an art worth understanding.

If those who operate engines would make it a part of routine to run a test upon them periodically, nine out of ten cases of serious troubles could be averted, as a falling off in efficiency usually precedes accident, due to poor adjustments or weakened parts. The article on gas engine testing may suggest some way of making such investigations possible in your plant.

From the viewpoint of a man in charge of a plant, an unusually interesting list of subjects are treated among the Letter Direct from the Plant. How the other fellow does it is always interesting, if his method is different from yours and points to dangers or errors which may occur, he has done you a real service. There are several "real services" to everybody in the letters in this issue.

To nearly everybody, an examination is as much a test of character as it is a test of his knowledge of the subject; confidence, doubt, rapid decision, honesty, bluff, guesswork and nearly the whole list of questions concerning a man's character can be answered by a competent examiner after a careful study of a man's examination papers. As a means, therefore, of developing character, taking an examination is an experience every man should have occasionally. Such questions as are commonly asked are frequently published in Practical Engineer and much self-confidence and a correct estimate of one's own ability can be gained by taking an examination "given by Practical Engineer" through its columns. The answers are always given either immediately or in some subsequent issue. Other topics of interest will also be found in the Questions and Answers department of this issue.

The relations between variable quantities encountered in engineering usually take place according to some definite law. This frequently may be expressed mathematically, but a more vivid conception can be given by the use of charts and curves. These charts are also valuable as time savers in making calculations. They have been used extensively in the Practical Reference Tables. In this issue are several of practical value.

Index for 1916

The index for Volume XX of Practical Engineer is now prepared and will be sent free to subscribers upon request.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Re-inforced Spiral Stack

WHEN the Standard Spiral Pipe Works erected its new plant in Chicago, it had occasion to install 2 stacks about 60 ft. high for one of the furnaces, and as an experiment formed the stacks from 2 pieces of 20-in. No. 14 gage Standard reinforced spiral pipe. After being erected, these stacks were without guy wires for 6 months, during which time there were a number of severe wind storms in the locality. Neither stack was affected in any way by the wind pressures, and both are giving excellent service.

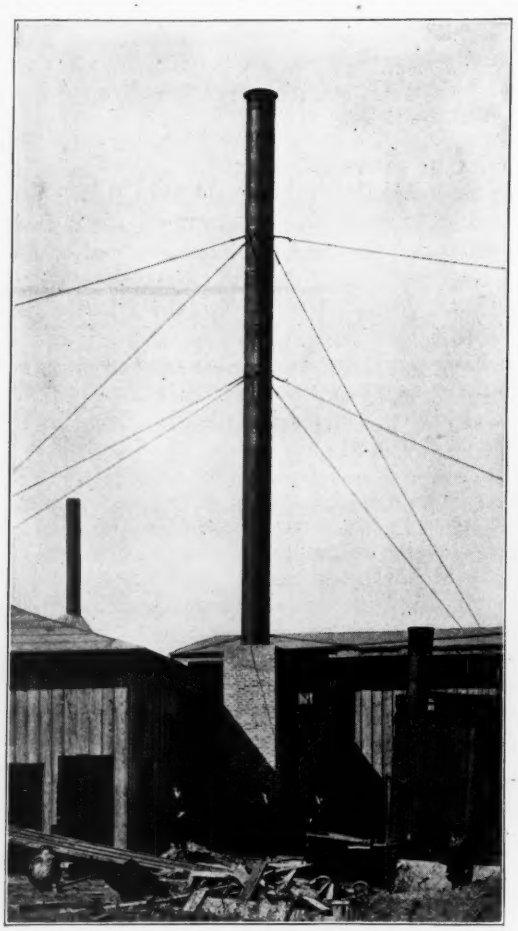


FIG. 1. 50-FT. STACK INSTALLED AT BRICK PLANT

Several engineers who visited the plant or talked with the company were informed of this novel smoke stack, and a 30-in. diameter stack 50 ft. high in one section has subsequently been furnished for a large brick plant located in Chicago. A photograph of this stack is shown in Fig. 1, and the interlocking seam of Standard spiral pipe in Fig. 2.

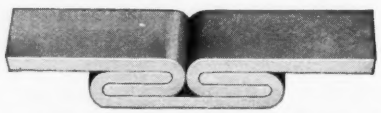
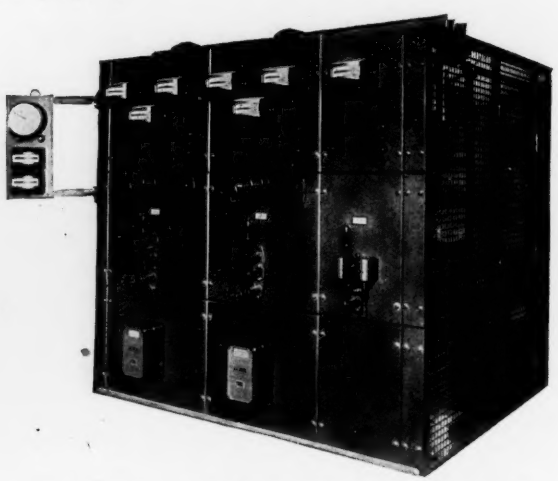


FIG. 2. SECTION SHOWING CONSTRUCTION OF SEAM

Advantageous features of this particular stack are its stiffness and strength, and ease of operation. It required only a gin pole about 25 ft. long, and some rope and tackle and 4 men to raise it. This stick has now been in service about 2 months and has given good satisfaction.

"Safety First" in Switchboard Construction

CLOSE co-operation between the manufacturers and large users of electrical machinery has resulted in the development of many devices to safeguard life and property.



DEAD FRONT ALTERNATING-CURRENT SWITCHBOARD

A recent development of importance along this line is the switchboard shown herewith which embodies several desirable features of safety and convenience. All live parts, except current and potential receptacles, are inaccessible from the front of the board and the live parts of these receptacles are recessed so that accidental contact with them is difficult.

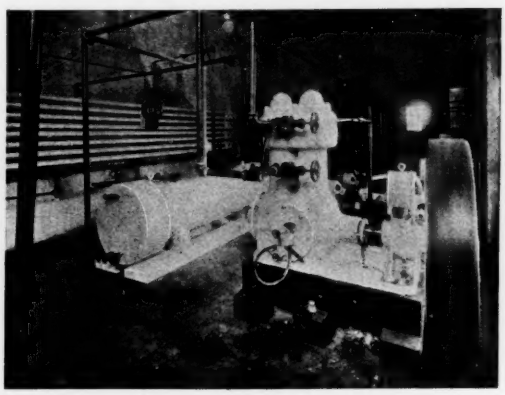
Grillwork screens afford protection against accidental contact with live parts in the rear of the board. Hinged doors provided with spring locks are placed one each side of the grillwork, making it impossible for anyone other than an authorized person holding the key, to enter the space at the rear of the switchboard.

Disconnecting switches are used between all oil circuit breakers and busbars and provide convenient and rapid isolation of the breakers from the bus for inspection, changing oil or repairs, without hazard. Instead of the usual calibrating switches back of the panel, this board is equipped with front of board calibrating receptacles which permit safe and convenient calibration of instruments and meters from the front. Insertion of plugs in the calibrating receptacles connects the testing instrument in series with the instrument under test. The board is also equipped with removable fuse receptacles of the screw-plug type which provide for a replacement of secondary potential transformer fuses from the front of the switchboard without the danger of contact with live parts.

The panels described are for general power and lighting service up to 3500 v., 25 to 60 cycles, and are manufactured by the General Electric Co.

Portable Ice Plant for Road Show

IT IS one thing to stage an ice ballet in the New York Hippodrome, where the show runs for an entire season, and quite another thing to transport a skating rink around the country with only a short run in each place. When it was decided to send the Hippodrome Company on the road, keeping intact the entire spectacles of "Around the World," including "Flirting at St. Moritz," the most brilliant ice ballet ever staged, the one serious drawback was the problem of furnishing a suitable ice pond. The adoption of the ice plant shown by the illustration proved to be the solution. The various units of this plant are transportable, each being mounted on a skid or stand, so that when the show closes it is only necessary to take down the piping, haul the different pieces of apparatus on a truck, pack them into a car and ship to the next showing place. To prevent the loss of time required to erect the plant and freeze the water, which takes 24 hr., duplicate outfits are used. While one is working in one city, the other is being set up at the next point, so that everything is in readiness when the company arrives. The first plant then goes to the succeeding point.



PORTABLE ICE PLANT IN OPERATION

Each plant consists of a 10-ton York compressor, with 2 cylinders each 6½ by 6½ in. driven by a 20-hp. direct-current Westinghouse motor, and a 60-kw. Westinghouse motor-generator set. Where direct current is available, the motors are operated from the power circuit, but as usually only alternating current is to be had, the motor-generator set is used to transform the alternating current into direct current for the operation of the motors.

The brine tank has a capacity of 1900 gal. The ice pond formed on the stage is 45 ft. long, 20 ft. wide, and 4 in. deep. While being frozen, the water is held in place on the stage by a canvas tub.

The Cox-Fulton Water-Cooled Mechanical Stoker

THE COX-FULTON Water-Cooled Mechanical Stoker, the result of 12 yr. of careful study and experiment, will, according to the manufacturers, The James A. Brady Foundry Co., Chicago, efficiently and satisfactorily burn nearly all kinds of coal found throughout the country and particularly so, high-coking, low-volatile coals.

FIG. 1. THE COX-FULTON WATER-COOLED MECHANICAL STOKER

Fuel is deposited in a hopper from where it is fed over a coking plate directly under the ignition arch by means of the coal pusher shown in Fig. 1.

Leaving the coking plate, the coal is delivered onto the inclined grate, which is built up of a series of stationary grates and alternate moving grates. These, which are attached to side frames, are caused to travel in a circular path by means of an eccentric riding on the stoker shaft. Due to this upward or lifting action of the movable grate, the stoker is automatic and absolutely positive in its feeding action, and thereby maintains a continuous, even distribution of the burning fuel over the entire grate area, and prevents the formation of clinkers and air holes. In addition, the constantly changing area of the air spaces prevents clogging with ashes, clinkers or foreign matter; the air opening is equal to 68 per cent of the entire grate surface.

A feature of interest is the provision made for automatically cooling all parts subject to destruction by the heat of the fuel by means of water taken from the boiler and circulated through these parts.

Each grate bar (also the hopper back) is water cooled along that portion in contact with the fire, casting into it an extra heavy 1¼-in. seamless steel tube especially

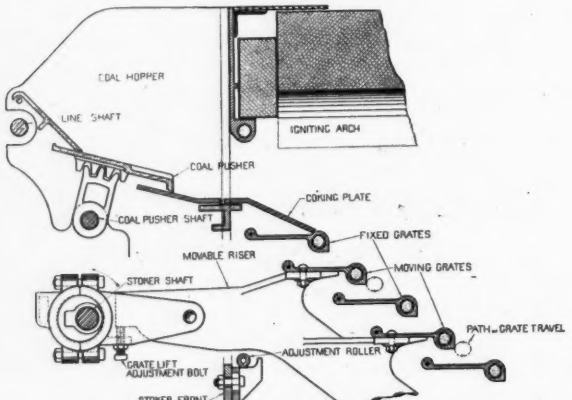


FIG. 2. ARRANGEMENT OF GRATES, COX-FULTON STOKERS

for the purpose and capable of withstanding a pressure of 2000 lb. per sq. in. Connections between the grate bars are made through return bends of the same tubing, and bronze-seated, loose-ring, extra-heavy flange unions, making leaks practically impossible.

By an arrangement of heavy bronze non-return check valves, the stoker water-cooled parts are in reality converted into a separate miniature tubular boiler, operating on the flash system. As long as there is any water in the boiler, the stoker water-cooling system automatically draws its supply from there and returns the steam generated into the steam space of the boiler. The flow of water through the stoker parts is therefore not continuous, but spasmodic, and during each movement passes from the stoker to the boiler with sufficient velocity to scour the inner surfaces of the tubing, preventing the formation of scale and sediment.

The ash dumping arrangement disposes of the ashes only, retaining the combustible coke in the furnace, and permits no inrush of cold air during the process of dumping. It is extremely simple and easy to operate, being practically balanced on central pivots.

Cox-Fulton Stokers are manufactured by The James A. Brady Foundry Co., of Chicago, Ill.

Corliss Valve Steam Trap

AFTER 8 yr. of testing under a variety of conditions, a steam trap using a Corliss type of valve has been brought out by the Plant Engineering and Equipment Co., of New York City.

This device, known as the Lindstrom Corliss valve trap, is formed with 6 parts: a cast-iron housing, the valve, valve seat, float arm, float and cover. From a recess counterbored into the chamber is fitted a lid which has a ground joint without packing. The valve mechanism is screwed to the inside of the cover, friction being minimized by having but one moving part and the easy sliding action of a rotary valve. As the condensation never entirely leaves the trap, the valve is always water sealed, thus making the escape of steam impossible and allowing any mud, scale or foreign matter collected at the bottom of the trap to remain un

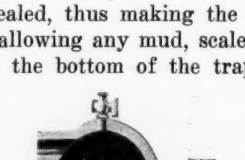


FIG. 1. CROSS SECTION OF LINDSTROM TRAP

disturbed at each discharge. Figure 1 shows the interior arrangement.

Positive action is assured by the manner in which the float is attached to both sides of the valve, the center of which is the fulcrum. This permits the use of a small float, which is tested under a pressure of 400 lb. per sq. in., and the connecting lever is so designed that it cannot be incorrectly assembled.

In Fig. 2 is shown, attached to the trap, the Penco thermo gage, which indicates by touch whether the trap is tight or leaking, and is built in several forms for use with any make or size of trap. This gage is made of brass throughout with disc radiator and spring cock extending above the trap within easy reach of the hand, with a ½-in. pipe connection leading into the water

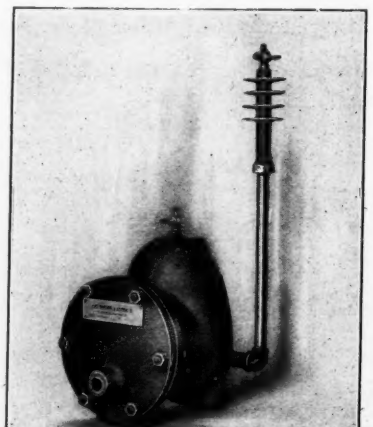


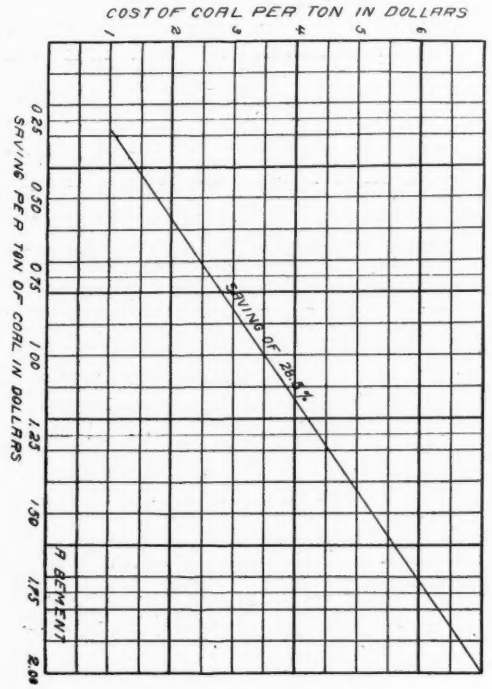
FIG. 2. TRAP EQUIPPED WITH THERMO GAGE

seal immediately above the trap valve. The gage is always in operation as long as it is connected to the trap, as there are no valves to close it off. When the trap is tight, the radiator is filled with water and is warm. When the trap is leaking the water siphons out, filling the gage with steam and causing it to become hot, so that one or more leaky traps in a bank of traps connected to a manifold return may instantly be detected.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

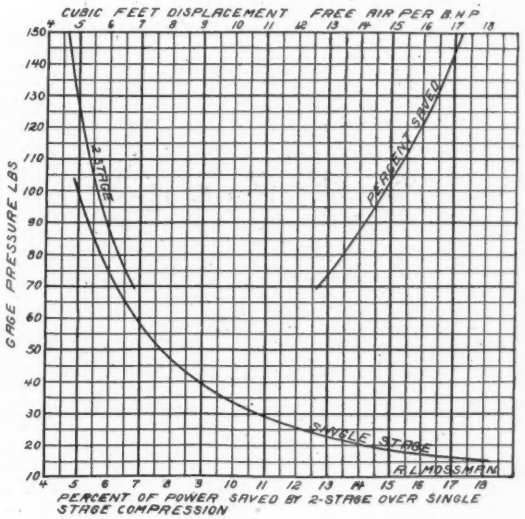
PRACTICAL ENGINEER

DIAGRAM SHOWING THE POSSIBILITIES OF SAVING IN FUEL COST, BY THE ATTAINMENT OF IMPROVEMENT OVER AVERAGE PREVAILING CONDITIONS, WITH COAL AT DIFFERENT PRICES



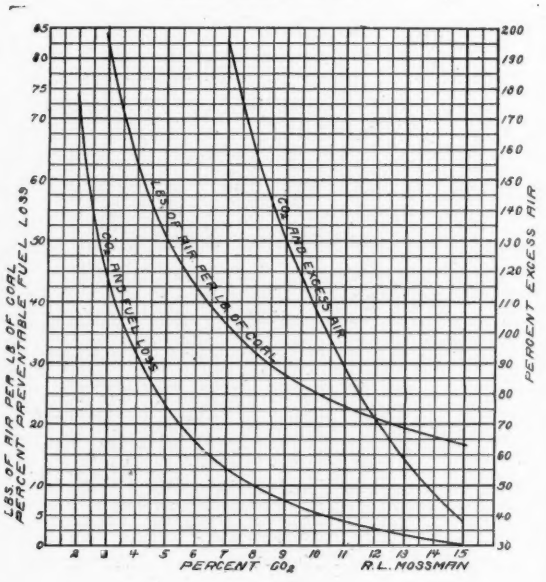
PRACTICAL ENGINEER

BRAKE HORSEPOWER OF AIR COMPRESSORS



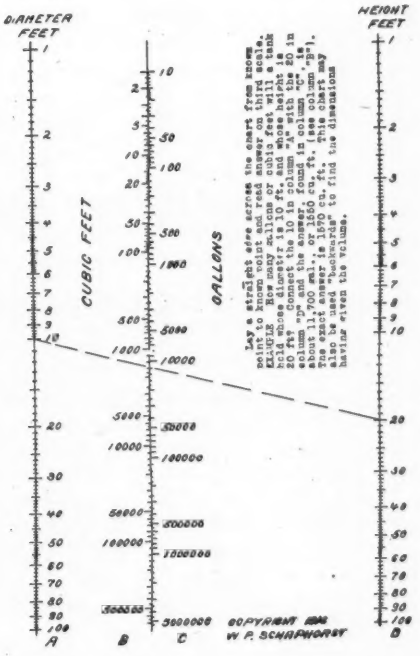
PRACTICAL ENGINEER

FUEL LOSS AND EXCESS AIR AT VARIOUS PERCENTAGES OF CO_2


LBS. OF AIR PER LB. OF COAL
PERCENT PREVENTABLE FUEL LOSS
LBS. OF AIR PER LB. OF COAL
CO2 AND FUEL LOSS
CO2 AND EXCESS AIR
PERCENT EXCESS AIR
PERCENT CO2
R.L. MOSSMAN

PRACTICAL ENGINEER

CHART FOR CALCULATING CAPACITY OF VERTICAL CYLINDRICAL TANKS



SPECIFIC GRAVITIES AND WEIGHTS OF VARIOUS LIQUIDS

Liquid	Deg. Baume	Specif. Grav.	Lb. Per U.S.Gal.	Lb. Per Cu. ft.
Alcohol, ethyl (at 32 deg. F.)	43	.807	6.72	50.3
" Methyl (" " " ")	43	.810	6.75	50.5
Ammonia (" " " ")		.623	5.19	38.9
Beer	5	1.034	8.62	64.6
Oils Linseed	19	.940	7.83	58.6
Turpentine (at 61 deg. F.)	31	.873	7.28	54.5
Lard (at 59 deg. F.)	22	.920	7.67	57.4
Cottonseed (at 61 deg. F.)	21	.926	7.72	57.7
Petroleum Oils	20	.9333	7.78	58.2
	30	.8750	7.29	54.6
	40	.8235	6.86	51.4
	50	.7777	6.48	48.5
	59	.7407	6.17	46.3
Ohio Crude	44	.8065	6.719	50.3
Cal. Ref.	43	.811	6.756	50.6
Light Penna. Crude	42	.8155	6.794	50.9
W. Va. Crude	41	.8205	6.836	51.2
Penna. Crude	38	.8345	6.952	52.0
Kansas Crude	35	.8490	7.073	53.0
Ill. Crude	33	.8595	7.160	53.6
Texas Crude	27	.8930	7.440	55.7
" "	26	.8990	7.490	56.1
Light Lub.	25	.9045	7.536	56.4
Heavy Lub.	17	.9530	7.939	59.5
Mexican "Ebano" Crude	10	1.000	8.331	62.36

CHART FOR CALCULATING DISPLACEMENT OF AIR

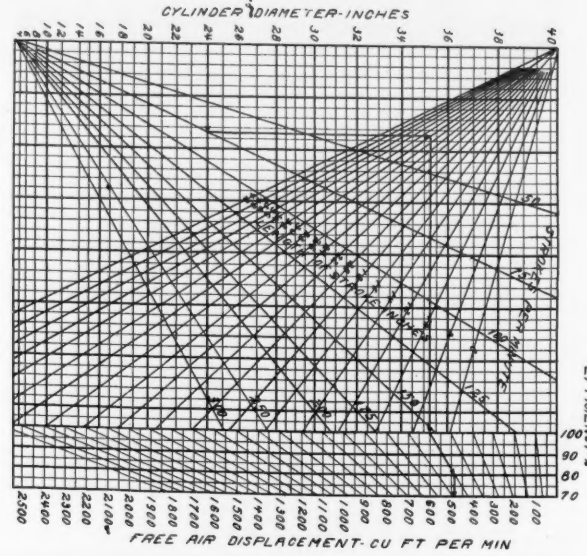


CHART FOR ESTIMATING COAL FED BY CHAIN GRATE STOKER

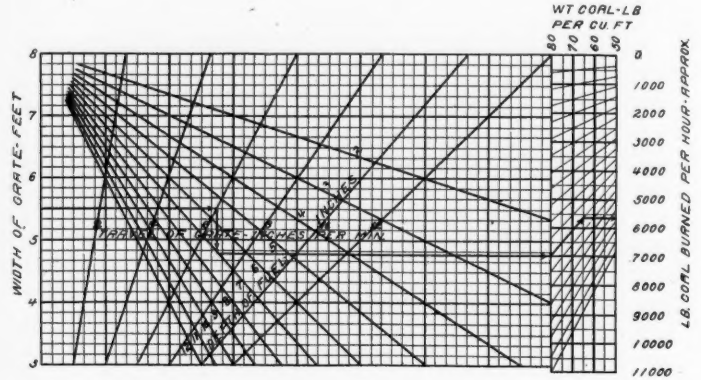
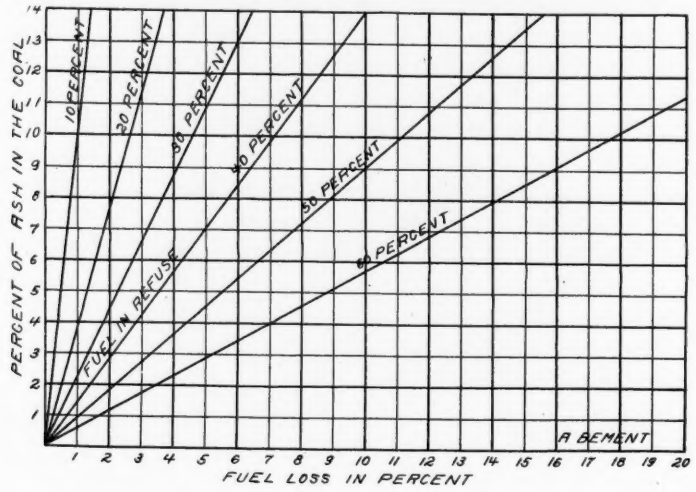


DIAGRAM SHOWING FUEL LOSS IN REFUSE; RADIAL LINES REPRESENT PER CENT OF FUEL IN THE REFUSE



Catalog Notes

BULLETIN NO. 102, "Humidity and Temperature Regulating Devices," containing 48 pages of description and illustrations of controlling devices to meet all commercial requirements, has just been issued by the Carrier Engineering Corporation, 39 Cortlandt St., New York.

The introductory pages explain how a system of control is dependent upon various factors, chief among which are the number and sizes of rooms, their contents, arrangement of machinery, source of heat and moisture, effect of air currents and the exact humidifying, dehumidifying, heating, cooling and drying or combination of these to be accomplished.

A copy of this bulletin will be mailed free on application to the Carrier Engineering Corporation.

AS A RESULT of underground excavation which is made in the process of mining, the earth's surface frequently subsides to an extent which interferes with the stability of buildings, railroads, and other facilities which may exist on the surface. Where subsidence is occurring or in the immediate future is likely to occur, building projects on the surface must take account of these facts.

The comparative newness of most of our mines is probably responsible for the fact that the subject only recently has attracted widespread attention. The subject is one which has recently been studied by the Engineering Experiment Station of the University of Illinois in co-operation with the State Geological Survey and the United States Bureau of mines. The investigators Professor L. E. Young and Professor H. H. Stoek, have summarized existing facts as presented by the literature on the subject, have conducted an extensive correspondence with mine operators and mine workers throughout the coal mining districts of the United States, and have studied local conditions as they now exist in the mining districts of western Pennsylvania, West Virginia, Maryland, and Illinois.

Results of these investigations are presented in Bulletin No. 91 of the Engineering Experiment Station, a book of 200 pages, well illustrated, copies of which may be obtained gratis upon request from W. F. M. Goss, Director, Urbana, Ill.

A NEW FOLDER descriptive of globe-shaped iron body gate valves, manufactured by Jenkins Bros., 80 White St., New York, has just been received.

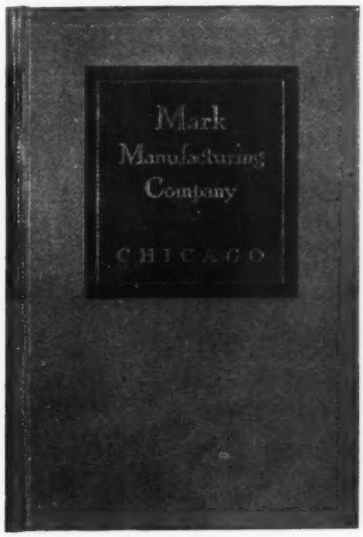
FROM THE Youngstown Sheet & Tube Co., Youngstown, Ohio, we have just received the company's large illustrated calendar for 1917.

A COMBINATION calendar and pamphlet relating to the treatment of fan belts has just been received from Cling-Surface Co., Buffalo, N. Y.

DART UNIONS and flanges are illustrated in their forms of construction, and price lists are given in a new circular from E. M. Dart Mfg. Co., Providence, R. I.

McAULEY AUTOMATIC TRAPS for gas, steam and compressed air are described and illustrated in a pamphlet lately received from The McAuley Automatic Trap Co., Imperial Power Bldg., Pittsburgh, Pa.

IN ITS CATALOG NO. 12 the Mark M'f'g Co. illustrates and describes the various piping specialties and well fittings manufactured by this concern. The book is made attractive with colored halftones and covers the field thoroughly, including wrought pipe, line and



drive pipe, well casings, boiler tubes, electric wire conduit, pipe unions, well points and strainers, well cylinders and valves, pipe cutters, vises, threading dies, stocks, etc.

IN A BOOKLET recently received from A. E. Krause, Jersey City, N. J., is described the Krause Absorbent Filter and its use in purifying boiler feed water of oil without the use of chemicals.

Trade Notes

THE GOULDS MANUFACTURING CO., of Seneca Falls, N. Y., one of the best known manufacturers of pumps, has just made announcement of a bonus of an extra month's salary given to all salaried employes. This includes all office employes, both at the home office and branches and all shop employes on the weekly and monthly basis. In November, this company also granted a wage increase of 10 per cent to all piece work, hourly and day men.

THE POSITION of Akron, Ohio, as the "Rubber Capital of the World" has been so well established in the public mind that it is doubtful whether anyone would question seriously the claims of the rapidly growing Buckeye City to the distinction it has won. A recent valuation of Akron industries for property taxation, completed by the auditing department of the county in which the city is located, brings out with striking clearness the predominance of the rubber manufacturing industry over any other of the many that have brought about an increase of approximately 300 per cent in the population of Akron during the past 10 yr.

The taxable value of the great plant of the B. F. Goodrich Co. alone amounts to almost half of the total of $43,896,440 placed upon the 168 industries located in Akron and Summit county. Just how the rubber

manufacturing business dominates in Akron, and the immensity of it, is shown by figures given in a recent article in one of Akron's newspapers, from which the following figures are obtained:

Total valuation of all Akron and Summit county industries, $43,896,440. The B. F. Goodrich Co., $20,392,830; Goodyear Tire & Rubber Co., $7,631,780; Firestone Tire & Rubber Co., $4,964,980; Kelly-Springfield Tire Co., $1,371,930; Miller Rubber Co., $1,121,910; Portage Rubber Co., $331,880; Swinehart Rubber Co., $459,270.

A total of $36,220,580 is credited to the rubber manufacturing industry, more than 4/5 of the entire manufacturing activities of Akron and its suburbs.

ORDERS TOTALING more than $2,700,000 have recently been received by the Westinghouse Machine Co., of East Pittsburgh, Pa., for equipping with propelling machinery 44 merchant ships, now under construction or contracted for at the yards of shipbuilding companies on both the Atlantic and Pacific coasts. The company also has in immediate prospects the equipping of 16 merchant ships in addition to the 44 above mentioned, bringing the total number of ships up to 60 and the total value of the orders for machinery to be supplied by the Westinghouse Machine Co., to approximately 3¾ million dollars. The ships are to be equipped with the latest refinements in the line of propelling machinery, consisting of Westinghouse turbines with double reduction gears, and with few exceptions, condensing equipment. The first ship which has been so equipped is the Malmanger, launched at the Chester Shipbuilding Co., Chester, Pa., on Aug. 26, 1916. The business above described covers strictly merchant ships and does not include orders received for propelling machinery for the United States Navy, or for foreign governments.

THE BLACKBURN-SMITH CORPORATION, 105 W. 40th St., New York, through purchase of the Filter Department of James Beggs & Co., has acquired all patents, records, patterns and rights for the manufacture and sale of the Blackburn-Smith feed-water filter and grease extractor and the Blackburn-Smith sewage ejector system. The engineers and agents previously identified with these products have been taken over in a body by the new corporation and will in future work under the direction of Irvin Kaufman, vice-president, who has supervised the manufacture, sale and installation of the Blackburn-Smith filter for the past 10 yr.

WARREN WEBSTER & CO., of Camden, N. J., announce that they have disposed of the business of their Air Conditioning Department, and that henceforth the Webster Air Conditioning apparatus will be manufactured and exploited by the Braemer Air Conditioning Corporation, Lafayette Building, Philadelphia, Pa.

H. W. BURSON, who organized the Colonial Supply Co., recently sold his interest in the Colonial Supply Co., and has organized a new concern under the name Burson Supply Co., with offices in the Arrott Building, Pittsburgh.

PRACTICAL ENGINEER

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POSITION WANTED—Young man, age 28, as engineer in New York or Brooklyn. Hold marine, stationary and refrigerator license. Day work, 8-10 hours, desires to go to school nights. Write for particulars. Box 452, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-15-1

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POSITION WANTED—As oiler, by young man, age 21, single. Willing to accept position in any city. Address Peter Stanys, 670 W. 18th St., Chicago, Ill. 12-1-3

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WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal; Washington, D. C. This is an excellent chance for a hustler who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

Wanted

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

FOUR COPIES of Practical Engineer for February, 1910, in good condition; we will extend your subscription for three months. Circulation Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio.

MARINE BOILERS WANTED—From 50 to 250 horsepower. We will pay cash awards for information that leads to a purchase. The Pittsburgh Boiler & Machine Co., Pittsburgh, Kans. 1-1-6

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FOR SALE—One Type M. P. 8 Pole 200 k.w. 210 r.p.m. 225 to 250 volt G. E. Generator direct connected to tandem compound Ideal Engine. Class A condition. Box 465, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-1-2

MOTORS FOR SALE—Two 500 hp., three-phase, 25-cycle. Dotterweich, 5 Hughes Ave.. Buffalo, N. Y. 1-15-1

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Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

Everything under the sun wears out after a time. Nothing is permanent. Even the great pyramid of Cheops will some day be worn to the ground. Things that are material no sooner reach their finished state than they begin to deteriorate.

Just a few things can be done to stave off the hand of Time. You have often observed property going to rack and ruin because of the lack of attention—the need of a coat or two of that preserving element, paint, for instance. And the cost to keep it in repairs is less than the cost of "reclaiming" it after it has been allowed to totter and fall.

Perhaps nothing depreciates as fast as machinery. Friction and vibration are two great reasons for this. The wear is always at the vital places. There are doctors to machinery who can put a crippled engine back into service and prevent a loss in efficiency. These men are always ready for emergency calls and it pays to keep them in mind.

Still, when a machine is beyond reparation it should be promptly supplanted by a new machine. Many a dollar is lost because of machinery that should be relegated to the scrap pile, but instead is allowed to crawl along at a questionable efficiency.

It pays in the end and pays handsomely to keep your equipment in the very best conidition possible—the prime-movers—the auxiliary equipment—the apparent trifles that can assist or impede the efficiency of the principals—all should be in the best of order to give top-notch service.

If there is something in your plant that needs repairing or something that should be ripped out and supplanted by the new or more modern equipment it is wise to get to it at once. A delay will mean a loss every day you delay and most likely a greater expense in the end. Order what you need through the advertising pages of Practical Engineer and be on the safe side.